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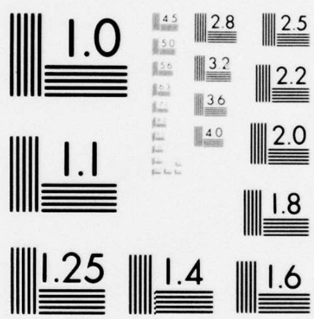

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OHIO RIVER BASIN

CONNOQUENESSING CREEK, BUTLER COUNTY

PENNSYLVANIA

BOYDSTOWN DAM

NDI No. PA 00270
PennDER No. 10-1

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

prepared for

DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

prepared by

MICHAEL BAKER, JR., INC.
Consulting Engineers
4301 Dutch Ridge Road
Beaver, Pennsylvania 15009

AUGUST 1979

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Approved for Public Release
Contract No. DACW31-79-C-0011

(P)

OHIO RIVER BASIN

(6) National Dam Inspection Program.

BOYDSTOWN DAM
BUTLER COUNTY, COMMONWEALTH OF PENNSYLVANIA.
(NDI No. PA 00270
PennDER No. 10-1),

Number Number

Ohio River Basin, Connoquenessing Creek, Butler County, Pennsylvania.

PHASE I INSPECTION REPORT,
NATIONAL DAM INSPECTION PROGRAM

(12) 110

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4301 Dutch Ridge Road
Beaver, Pennsylvania 15009

(11) Aug 79

(10) Chuan Yuan/Chen

410 795

JOB

PREFACE

This report is prepared under guidance contained in the "Recommended Guidelines for Safety Inspection of Dams," for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I Inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

Boydstown Dam, Butler County, Pennsylvania
NDI No. PA 00270, PennDER No. 10-1
Connoquenessing Creek
Inspected 27 June 1979

[cont'd from p. i]

ASSESSMENT OF GENERAL CONDITIONS

Boydstown Dam is classified as a "Small" size - "High" hazard dam. The dam and reservoir, owned and operated by the Western Pennsylvania Water Company, are used for water supply.

Based upon observations made during the visual inspection, data available from the Pennsylvania Department of Environmental Resources' (PennDER) files, and information obtained from interviewing representatives from the Western Pennsylvania Water Company, the dam is considered to be in very poor overall condition.

Detailed hydraulic/hydrologic evaluations performed by Burgess and Niple, Limited, and supplemented by Michael Baker, Jr., Inc., in accordance with procedures established by the Baltimore District, Corps of Engineers, for Phase I Inspection Reports, revealed that the spillway will not pass the Probable Maximum Flood (PMF) without overtopping the dam. The analysis indicated that the spillway will pass only 30 percent of the required PMF before overtopping will occur. As a result of this analysis and others noted in Section 5, the spillway is considered "seriously inadequate." The owner should immediately initiate an engineering study to develop recommendations for remedial measures to reduce the overtopping potential of the dam.

In summary, Boydstown Dam is classified as an "Unsafe" - "Non-emergency" condition dam.

The overall condition of the dam was assessed to be very poor because the upper half of the spillway is in such a deteriorated condition that significant damage to the structure may occur if large flows were to pass through the spillway. In addition, several features of the dam do not meet current design standards; the 7 foot crest width, the lack of an internal drainage system, the absence of positive cut-offs along the outlet and water supply pipes, and the

lack of information concerning the details and condition of the outlet works.

It is recommended that the owner give consideration to reconstruction or breaching the dam as an alternate to performing necessary repairs to the structure. Reconstruction of the dam to meet current design standards would be one method of providing safety for the structure without an extreme amount of expense, considering the relatively narrow valley width. If, however, the economics do not warrant proper repairs or reconstruction, then the reservoir should be drawndown and the dam breached. If the owner feels the dam and reservoir constitutes an important part of their overall water supply system, then the following items should be performed without delay. Items 1, 2, and 3 below should be designed by a qualified professional engineer experienced in the design of earth dams.

1) Recommendations for reducing the overtopping potential of the dam should be developed and implemented. (Raising the top of dam without reconstructing the upper half of the spillway would not be acceptable because the spillway in its present condition would not withstand any high velocity discharges.)

2) The outlet works should be evaluated and the type, size, and location recorded on engineering drawings for future reference. If any of the outlet pipes are not provided with upstream closure, then procedures should be developed for rapid closure at the upstream end in the event of a pipe rupture.

3) The upper half of the spillway should be reconstructed to provide continued stability of the spillway structure against high discharge flows. (As mentioned previously, this can be performed in conjunction with providing the necessary spillway capacity to reduce the overtopping potential of the dam.)

4) The dense vegetation on the dam should be cleared and replaced with well maintained grass.

5) Riprap or other types of erosion control should be placed on the upstream slope to protect against erosion.

6) Proper inspection and maintenance procedures should be developed and implemented. Periodic inspection of the seepage at the right abutment

toe should be included as a part of the inspections. The quantity and turbidity of the seepage should be recorded to identify any changing conditions.

7) Access to the dam should be improved to enable personnel to provide surveillance during flood discharges from Boydstown Dam and high reservoir stages of Lake Oneida.

In addition, the emergency operation and warning system for Lake Oneida should be expanded to include round-the-clock surveillance of Boydstown Dam during periods of unusually heavy rain or in the event of an emergency at the dam.

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
CHUAN YUAN CHEN
ENGINEER
No. 14840-E

Submitted by:

MICHAEL BAKER, JR., INC.

C. Y. Chen

C. Y. Chen, Ph.D., P.E.
Engineering Manager-Geotechnical

Date: 24 August 1979

Approved by:

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS

James W. Peck

JAMES W. PECK
Colonel, Corps of Engineers
District Engineer

Date: 12 Sep 79

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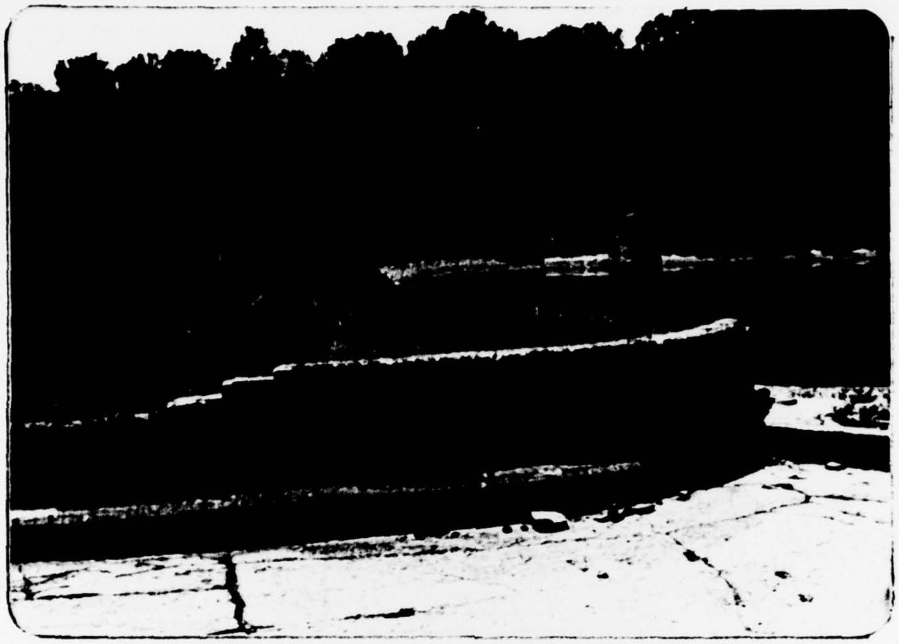
PLATES

Note: No plates which show the current configuration of the dam are available. Please refer to the field sketch for schematic drawings of the dam.

APPENDICES



Overall View of Dam from Left Abutment

Overall View of Downstream Portion of Dam from Left Abutment

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
BOYDSTOWN DAM
NDI No. PA 00270, PennDER No. 10-1

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority - The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

b. Purpose of Inspection - The purpose of the inspection is to determine if the dam constitutes a hazard to human life or property.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances - Boydstown Dam is a diaphragm earthfill embankment approximately 28 feet high (maximum) and 330 feet long. The dam when originally constructed did not contain a corewall; however, a 100 foot section at the right abutment was reconstructed after being overtopped and a masonry stone corewall was installed. Again, after an overtopping failure in the center of the embankment, a concrete corewall was installed from the left end of the masonry stone corewall to the left abutment of the dam. The embankment, in the plan view, is shown to have a slight convex curve downstream. The upstream and downstream slopes are 2.5H:1V (Horizontal to Vertical) and 2H:1V, respectively.

The spillway, at the present time, is located at the left abutment of the dam. The spillway is uncontrolled and the broad-crested weir is 60 feet long (perpendicular to flow). The flow, after passing over the weir, travels through a flat concrete paved channel before cascading down a series of concrete steps into the stilling basin. The right side of the discharge channel has a training wall 8 feet high and is made of masonry stone for the upper half and concrete for the lower half. The left side of the channel is sloped back and rubble-lined for the first half and then is a concrete training wall along the series of steps.

[cont'd on p. 11]

The riser tower is circular and consists of masonry stone. Three gated intake levels are located on the upstream half of the tower. The flow then enters a gated pipe (believed to be a 16 inch water supply line) and subsequently discharges below the dam from a gated "wye" on the water supply line. According to the owner's personnel, this water supply line is no longer used for water supply. In addition, the owner's personnel indicated that a 20 inch blow-off pipe and a 24 inch wooden water supply pipe run from the intake tower to the downstream pool and treatment plant respectively. (It should be noted here that some confusion exists as to the outlet works in the dam since no drawings of the outlet works are available from either the Pennsylvania Department of Environmental Resources' [PennDER] file or from the owner. The 1915 Water Supply Commission Report details the outlet works at that time according to the information available. The water company's information is based upon a diver's description approximately five years ago when repairs were performed in the intake tower. This information has been gathered from the recollection of the people involved at that time.)

b. Location - Boydstown Dam is located in Oakland Township, Butler County, Pennsylvania, approximately 900 feet east of Boydstown, Pennsylvania. The coordinates of the dam are N. 40° 56.3' and W. 79° 50.6'.

c. Size Classification - The maximum height of Boydstown Dam is 28 feet. The reservoir volume to the top of the dam at El. 1078.4 feet is 514 acre-feet. Therefore, the dam is in the "Small" size category.

d. Hazard Classification - Lake Oneida Reservoir and Dam (NDI No. PA 00272) are located immediately downstream from Boydstown Dam. In the event of a failure of Boydstown Dam, it is likely that Lake Oneida Dam will be overtopped and will subsequently fail. Lake Oneida Dam and Reservoir have been assigned a "High" hazard classification by GAI Consultants, Inc., Phase I Inspection Report, dated September 1978. Therefore, Boydstown Dam is also considered in the "High" hazard category.

e. Ownership - The dam and reservoir are owned and operated by the Western Pennsylvania Water Company, Butler District, 105 Lincoln Avenue, Butler, Pennsylvania 16001.

f. <u>Purpose of Dam</u> - The dam and reservoir are used for water supply purposes and limited recreational use.

g. <u>Design and Construction History</u> - The construction of the dam was started sometime prior to 1896 to provide a water supply reservoir along Connoquenessing Creek above an area of salt water pollution (as a result of oil wells). Mr. George Schaffner was the contractor for the original construction of the dam. The dam was started by private concerns and then sold to the Butler Water Company (predecessor to Western Pennsylvania Water Company, present owner of the dam) after a lack of funds prevented the completion of the dam. The Butler Water Company then finished the dam in 1896.

On 27 July 1897, after a heavy rain, a portion of the embankment near the right end of the dam washed out after being overtopped. Subsequently, the breach was repaired under the direction of Mr. James Morrow.

On 28 August 1903, after a rainfall estimated at 8 inches in 4 hours and 15 minutes (the amount of rainfall was heavily disputed in the information reviewed) the embankment was again overtopped and a different segment of the embankment washed away. The embankment was again repaired under the direction of Mr. James Morrow.

During the afternoon and evening of 1 October 1911, a precipitation of 2.9 inches fell in approximately 4 hours, resulting in a depth of flow through the spillway of 67 inches. During this flood, a timber apron located at the downstream end of the spillway was washed away from the timber sheet piling to which it was fastened. No damage to the embankment occurred and the apron was replaced with a concrete stilling basin.

As a result of the noted failures of the dam and because of deterioration, the spillway for the dam has undergone numerous changes and reconstructions. It was noted that the original spillway (30 foot long, perpendicular to the flow, with the crest 6.5 feet below the top of embankment) was located in the center of the embankment. This timber-lined and timber cribbed supported spillway was removed and replaced after the 1897 failure of the dam. A new spillway, 50 feet long and 6.8 feet deep, was constructed of masonry stone and mortar

at the left end of the dam. Subsequent to the 1903 failure, the embankment was raised to a level 8 feet, 2 inches above the spillway crest and the spillway was revised from a long channel to a broad-crested weir with series of concrete steps below it. As noted above, the timber spillway apron was replaced with a concrete stilling basin after its failure in 1911.

As a result of an inspection performed by a representative of the Water Supply Commission in 1915, the spillway size was increased in 1916 to a 60 foot length (perpendicular to flow). In addition, the left training wall was removed and the left side cut back to a 2H:1V masonry rubble-lined slope. During the intervening years, between 1916 and the present, the spillway has been inspected and noted to need immediate repairs. The known years when repairs were performed to the spillway include 1934, 1948, and 1953. It should be noted that in 1949, an additional study was performed on the spillway at Boydstown and it was decided that additional spillway capacity was necessary. At that time the spillway capacity was evaluated to be 3860 c.f.s. and that the spillway needed a capacity of 14,700 c.f.s. The computed 3860 c.f.s. is only 26 percent of that which was calculated to be required. No known changes were performed on the spillway to meet the desired discharge capabilities.

h. Normal Operational Procedures - The spillway is uncontrolled and the outlet pipe is at least partially open (if not fully open) and the controlling valve is never adjusted. The dam is visited daily for checking the reservoir level and completing a maintenance check list.

1.3 PERTINENT DATA

a. Drainage Area (square miles) - 13.6

b. Discharge at Dam Site (c.f.s.) -

Maximum Flood -	Unknown
Spillway Capacity (at Pool El. 1078.4 ft.) -	3100

c. Elevation (feet above Mean Sea Level [M.S.L.]) -

Top of Dam -	1078.4
Maximum Pool (Hydrologic and Hydraulic Analysis[1]) -	1082.3
Spillway Crest -	1071.2
Streambed at Centerline of Dam[2] -	1050±
Maximum Tailwater of Record[3] -	1063.6

d. Reservoir (feet) -

Length of Maximum Pool -	6650
Length of Normal Pool -	3540

e. Storage (acre-feet) -

Top of Dam (El. 1078.4 ft.) -	514
Normal Pool (El. 1071.2 ft.) -	236

f. Reservoir Surface (acres) -

Top of Dam (El. 1078.4 ft.) -	52
Normal Pool (El. 1071.2 ft.) -	24

g. Dam -

Type -	Diaphragm earthfill
Length (feet) -	330
Height (feet) -	28
Top Width (feet) -	7
Side Slopes - Upstream -	2.5H:1V
- Downstream -	2H:1V
Zoning -	None
Impervious Core -	Masonry stone core wall right 100 feet, 2 foot thick concrete core wall remaining length of dam.
Cut-off -	Unknown
Grout Curtain -	None
Drains -	None

h. Diversion and Regulating Tunnel - None

[1]Maximum reservoir level during the Probable Maximum Flood as determined by Burgess and Niple, Limited.
[2]Estimated from top of dam elevation and designated height of dam.
[3]From Phase I Inspection Report - Lake Oneida Dam.

i. <u>Spillway</u> -

Type -	Broad-crested weir
Length of Crest (feet) -	60
Crest Elevation (feet M.S.L.) -	1071.2
Gates -	None

Upstream Channel - Riprap-lined reservoir shore.

Downstream Channel - Flat concrete paved channel for first half exiting into a series of concrete steps. A stilling basin is located at the end of the steps and Lake Oneida normally forms the tailwater elevation in the stilling basin.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Boydstown Dam was completed in 1896; therefore, it is estimated that it was designed based on local experience for similar dams. The only design information available for this dam is PennDER's File No. 10-1. Information in this file includes:

1) "Report Upon the Boydstown Dam of The Butler Water Company," prepared by the Water Supply Commission of Pennsylvania (predecessor to PennDER) and dated 20 January 1915.

2) Design drawings showing the plan view of the dam and changes to the spillway.

3) Various correspondence, memorandums, and inspection reports.

2.2 CONSTRUCTION

The construction of the dam was started sometime prior to 1896. The construction of the dam was completed in 1896 by the Butler Water Company after others were financially unable to complete it. The original contractor is reported to have been Mr. George Schaffner.

The dam, as originally constructed, consisted of an "earth and clay" embankment with a timber plank core wall. The embankment was reportedly "to have been constructed upon the natural surface of the valley, the selected material being deposited on the upstream side and the inferior material on the downstream side of the core wall, in thin layers and compacted by teaming." The embankment, in the plan view, was constructed with a slight convex curve downstream. The timber core wall consisted of two 1 inch layers of oak planks placed in a trench excavated to the top of rock. Lagging (2 by 4 inches at the base and 2 by 6 inches at the top of the planks) secured the planks.

The original spillway was located in the center of the embankment at the stream channel, and was formed of 2 inch planks, spiked to the top of rock and clay filled timber cribs. It was reported to have been 30 feet in length, with its crest 6.5 feet below the top of the embankment. The training walls of this spillway were formed by timber bulkheads, which supported and protected the sides of the embankment. The

vertical upstream face of the timber crib supported the timber cut-off wall and the downstream end was protected from backwash and undermining by sheeting which extended from the floor of the channel to the bedrock.

The original outlet works consisted of a stone masonry circular intake tower with a 12 foot inside diameter and three gated controlled openings. (This intake tower and gates are still present and functional.) A 12 inch terra cotta pipe passing through the embankment and controlled by a gate within the intake tower was used for water supply. Parallel to the terra cotta pipe was a 30 inch square wooden flume constructed of 2 by 4 inch timbers spiked together. This flume was also controlled by a gate and was intended to act as the drawdown facility (and supplement to the spillway). During the first winter after construction, the terra cotta pipe had to be replaced by a 16 inch cast-iron main and valve because the weight of the embankment crushed the terra cotta pipe.

On 27 July 1897, after a heavy rain, (no record of rainfall available) a portion of the embankment approximately 100 feet in length between the right (west) end of the dam and the spillway (the wooden spillway which was then in the center of the dam) was overtopped and washed out. The breach was repaired as soon as possible after the failure under the direction of Mr. James Morrow. As a part of the repair, a 24 inch rubble masonry core wall extending from rock to the top of the dam was constructed in place of the timber core wall in the breached area.

In 1897, the timber spillway at the center of the dam was removed and replaced with a 50 foot crest length spillway at the left end of the dam. The structure of masonry stone and mortar was placed on the natural ground surface. The floor of the channel, concrete paved, had a nearly level slope from the crest of the spillway to the discharge chute. At the end of the chute was a heavy timber apron, secured to timber sheet piling at the upstream end.

The outlet works were also revised in 1897. A 16 inch cast-iron water supply pipe ran from inside the intake tower to a pumping station (location unknown) downstream from the dam. A 24 inch cast-iron blow-off pipe was also installed with the upstream end open to the reservoir and the downstream end regulated by a gate valve. The water supply pipe was also provided with a gate valve on the downstream side of the embankment.

On 28 August 1903, precipitation estimated at 8 inches in 4 hours and 15 minutes (a later memorandum in the PennDER File reports that a value of 3.19 inches reported by the Weather Bureau is more representative of the actual average precipitation than the unofficial value of 8 inches obtained by farmers measuring the rainfall in buckets) occurred and caused the embankment to be overtopped to a depth of 12 inches at a low spot on the embankment. This low section subsequently washed out. It was reported that the width of the breach was 130 feet and was located between the new spillway and the portion of the embankment that was breached in 1897 (this would be in the center and a little left of center of the dam). At the time of the flood, the spillway crest had 24 inches of flashboards on it.

Repairs were started as soon as possible after the flood under the direction of Mr. James Morrow. A 24 inch thick concrete core wall was then constructed from the left end of the dam and connected with the masonry stone core wall constructed in 1897. The core wall was reported to be constructed upon the rock foundation and extending to the top of the embankment. The breach area of the embankment was then repaired with "clay spread in thin layers, wetted and tamped." The entire length of the embankment was then raised approximately 1.5 feet above the previous top of dam elevation. (This made the top of the embankment 8 feet, 2 inches above the spillway crest elevation.) Changes were also made to the spillway at this time. These changes consisted of plugging the sockets for flashboard braces and revising the spillway from a long level section channel at the crest to a broad-crested weir with a series of concrete steps carrying the discharge away. (This is estimated to have increased the hydraulic capacity of the spillway.)

During the afternoon and evening of 1 October 1911, a precipitation of 2.9 inches fell in 4 hours, resulting in 67 inches of water passing through the spillway (with the blow-off pipes open). During this flood, the timber apron at the downstream end of the spillway channel washed away. This apron was then replaced with a concrete stilling basin with saw-tooth energy dissipators at the upstream end of the basin.

On 12 January 1915, a representative of the Water Supply Commission made an inspection of the dam and subsequently wrote a report dated 20 January 1915 from which most of the above information was obtained. As a result of this inspection, it was recommended that the spillway be revised to be capable of discharging

6750 c.f.s. This figure was later reduced to 4100 c.f.s. This inspection also indicated that the plunge pool for the outlet pipe was riprapped and that a "wye" had been placed on the 16 inch water supply pipe. The branch pipe of the water supply pipe outletted into the plunge pool and was gated to be used for drawdown if necessary.

In 1916, the spillway was enlarged from a 50 foot wide rectangular channel to a 60 foot wide channel at the base with the left side cut back on 2H:1V slope. The slope was protected with hand placed masonry rubble riprap.

As a result of various inspections performed by Water Supply Commission representatives (and other predecessors of PennDER), the spillway was repaired in 1934, 1948, and a major reconstruction of the bottom half of the spillway in 1953. In 1953, the stilling basin was modified as a result of the reconstruction, with the energy dissipator blocks being installed at the downstream end of the stilling basin.

In 1916, seepage was reported exiting from the toe of the slope of the dam at the right abutment and the right hillside near the dam. Seepage weir measurements recorded in 1916 and 1917 indicate a relationship between the level of the reservoir and the volume of seepage exiting this area. This seepage was observed during various inspections performed from 1916 to 1948. The last inspection noting the seepage (1948) described it as "heavy" and that it would probably fill a 6 inch or 8 inch tile pipe. The only other inspection report available since 1948 was an inspection performed on 29 April 1964. This inspection report did not indicate that any seepage was present; however, it also did not indicate the reservoir level at the time of inspection.

According to a representative of the Western Pennsylvania Water Company, some repair work was performed in the intake tower approximately five to ten years ago. He did not know the details but indicated that the stems and valves were reconditioned or replaced.

2.3 OPERATION

The blow-off pipe is reportedly kept open at all times and is not regulated. The reservoir level is recorded and records are available back to 1954. In the fall of 1978, the water company started procedures for daily inspection of the dam and a check list for items observed for these inspections was instituted.

2.4 EVALUATION

a. Availability - The only design information available consisted of PennDER's File No. 10-1. Some of the history of the dam has been summarized above but the 1915 Water Supply Commission report contains most of the available information on the construction of the dam. No drawings showing a cross section of the embankment are available. No drawings showing information about the intake tower, blow-off pipes, outlet structure, location of water supply lines, foundation conditions, embankment zoning, and incorporation of an internal drainage system are available.

b. Adequacy - The information available is adequate for a Phase I Inspection of this dam.

c. Validity - Much of the information is based upon the Water Supply Commission report. The information contained in that report was obtained by reviewing any information available at that time and by interviewing the people associated with the operation and repairs performed to the dam. Based upon the field observations and experience with the Water Supply Commission reports on other dams, it is concluded that the information is the most complete and valid information available excepting the noted modifications performed on the dam after 1915.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General - The inspection was performed on 27 June 1979 and no unusual weather conditions were present. The pool was 5.6 feet below the level of the spillway crest at the time of inspection. The dam and appurtenant structures were in very poor overall condition. Noteworthy deficiencies are described briefly below. The complete visual inspection check list and field sketch are presented in Appendix A.

b. Dam - Clear seepage was observed exiting from the toe of the right hillside approximately 50 feet downstream from the junction of the embankment and right abutment. The estimated rate of flow was 2 g.p.m. from a fractured sandstone formation.

The embankment is covered with dense vegetation and small trees, making the visual inspection of the embankment and toe difficult. The crest of the embankment is only 7 feet wide and consists of sandy and clayey silt (ML-CL). The riprap on the upstream face has deteriorated and weathered to the point that the right side does not appear to have any riprap. Some minor wave erosion was observed on the right-center of the dam. No observation of horizontal alignment could be made because of the original slightly curved plan of the dam and no detailed "as built" drawings. The top of dam survey indicated a 0.5 foot difference between the left and right ends of the dam.

c. Appurtenant Structures - The spillway, especially the upstream half of the discharge channel and the right training wall, is very deteriorated. Cracking and undermining of the concrete slab has occurred (see Photo 9 for an example). Also, the right training wall at the entrance to the spillway has several of the sandstone blocks missing and is tilted into the spillway several inches (see Photo 10). The downstream half of the discharge channel and the stilling basin appeared to be in good condition; however, some cracking has occurred on the vertical face of several of the steps.

The intake tower was in fair condition with only a couple of boards on the walkway to the tower starting to rot away. The mortar between the

stones appeared to be in fair condition; however, the submerged portion of the tower could not be checked. The valve stem for the lowest level intake was disconnected at the time of the inspection. The remainder of the valves (gates) appeared to be functional but in need of preventive maintenance.

The outlet structure and outlet conduits were totally submerged and could not be examined. The outlet conduit was at least partially open and flow was entering Lake Oneida at the time of the inspection.

d. Reservoir Area - The area surrounding the reservoir is moderately sloping and highly forested. The reservoir at the time of inspection was 5.6 feet below the spillway crest elevation. No problems were observed in the reservoir area.

Upstream from the reservoir are several small farm ponds, one of which was examined. The others were on posted private property and were not examined. It is felt that these ponds will not significantly affect Boydstown Dam.

e. Downstream Channel - Lake Oneida Dam and Reservoir (NDI No. PA 00272) are located immediately downstream from Boydstown Dam. It has been reported that approximately 60 to 80 people might be affected by failure of Lake Oneida Dam. Since failure of Boydstown Dam is likely to cause a failure of Lake Oneida Dam under present conditions, and no other residences were located in low-lying areas along Lake Oneida shoreline, it is concluded this same approximate number of people would be affected by failure of Boydstown Dam.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

There are no formal written procedures in the event of impending failure of the dam. The condition of the dam is reportedly checked every day by personnel from the water company. At the time of the inspection, the drawdown facilities were at least partially open and according to water company personnel, remain in that position all the time.

At the present time, formal emergency procedures are being developed for Lake Oneida Dam. It is recommended that these emergency procedures be extended to include emergency operation and surveillance of Boydstown Dam.

4.2 MAINTENANCE OF DAM

The Western Pennsylvania Water Company is responsible for maintenance of the dam. At the present time, the maintenance of Boydstown Dam is very inadequate. It is recommended that formal maintenance procedures be developed and implemented, including upgrading the access to the dam.

4.3 MAINTENANCE OF OPERATING FACILITIES

The Western Pennsylvania Water Company is responsible for maintenance of the operating facilities. Although maintenance of these facilities has been performed at various times in the past, no formal schedule or record of the maintenance is presently in use. It is recommended that operation and preventive maintenance schedules be developed and implemented.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

The formal emergency warning system currently being developed for Lake Oneida Dam should be adapted to include Boydstown Dam.

4.5 EVALUATION OF OPERATIONAL ADEQUACY

According to information contained in the PennDER file for this dam, the outlet pipe for this dam is open to the reservoir and does not have a closure on the upstream side of the embankment. Since a number of uncertainties exist as to the location and condition of this conduit, it is recommended that an investigation be performed at a time when Boydstown Reservoir is at low pool. Also,

the lower portion of the riser, intakes, and gates should be examined at the same time. When the pool of Lake Oneida is low, it is recommended that a detailed inspection of the outlet structure and outlet works be performed.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data - No hydrologic or hydraulic design calculations are available for Boydstown Dam.

b. Experience Data - On 27 July 1897, following heavy rains, a 100 foot wide section of the embankment washed out as the result of overtopping of the dam. On 28 August 1903, the dam was again overtopped by approximately 12 inches resulting in a 130 foot long breach in the embankment. The rainfall over the watershed prior to the failure was estimated at 4.2 inches during a 4.25 hour period. The maximum discharge from the dam was estimated at 4300 to 4800 c.f.s. On 1 August 1911, the timber apron at the lower end of the spillway was destroyed as the result of excessive discharges through the spillway. The storm, 2.9 inches of rainfall in 4 hours, resulted in 67 inches of flow passing through the spillway and a maximum discharge from the reservoir of approximately 2450 c.f.s.

No failures of the dam or its appurtenances have occurred since 1911. However, the spillway has been activated numerous times. On 29 August 1923, the reservoir rose to a level of 56 inches above the spillway crest. Reservoir stage records have been maintained by the owner since 1954. The largest flood since that time occurred in 1954 when the reservoir rose 52 inches above the spillway crest following 3.3 inches of rain in the preceding 24 hours.

c. Visual Observations - The right training wall of the spillway, near the control section, is cracked and horizontally separated at the top of the wall by several inches. Generally, the upper end of the spillway is deteriorated and in poor overall condition. Structural failure of the spillway could possibly occur in the event of a storm equal to or greater than that of 1954.

d. Overtopping Potential - Boydstown Dam is a "Small" size - "High" hazard dam requiring evaluation for a spillway design flood (SDF) in the range of the 1/2 Probable Maximum Flood (1/2 PMF) to the Probable Maximum Flood (PMF). Oneida Dam, located immediately downstream from Boydstown Dam, is an "Intermediate" size - "High" hazard dam which has been evaluated

for a SDF equal to the PMF. In view of this, the PMF was also chosen as the SDF for Boydstown Dam, since an overtopping failure of this dam could significantly affect the hydraulic capabilities of Oneida Dam.

Hydrologic and hydraulic analysis of the Boydstown Dam was performed by Burgess and Niple, Limited as part of their detailed study of the Oneida Dam just downstream. As their analysis appears to be reasonable, the results of their study were utilized in this study.

A brief description of the analysis performed by Burgess and Niple is as follows. Additional information is contained in Appendix D of this report. The runoff hydrograph for the watershed was computed by the unit hydrograph method. The unit hydrograph for Boydstown Dam (and Oneida Dam) was constructed by transforming unit hydrographs from four other watersheds in the same hydrologic region having similar basin characteristics. Stage versus storage data was determined from recent aerial mapping. The U.S. Army Corps of Engineers' Water Surface Profiles computer program, HEC-2, was used to develop the spillway discharge rating.

The hydraulic capacity of the dam, reservoir, and spillway was assessed by utilizing the U.S. Army Corps of Engineers, Flood Hydrograph Package, HEC-1. The PMF hydrograph developed as part of this analysis had a peak discharge of 12,180 c.f.s., using a 72 hour probable maximum precipitation (PMP) of 29.4 inches. The results of this routing indicate that the dam would be overtopped by 3.9 feet and 1.9 feet by the PMF and 1/2 PMF respectively. The dam is capable of passing a flood of only 30 percent of the PMF.

e. <u>Spillway Adequacy</u> - The dam, as outlined in the above analysis, would be overtopped by the PMF. The criteria for spillway adequacy determination requires an estimate of the downstream damage increase during overtopping by 1/2 PMF conditions. Therefore, the following conditions, as well as historical evidence, were used as the limiting criteria which are likely to cause failure of this dam.

1) Depth of overtopping of 1.0 foot or greater.

2) Duration of overtopping in excess of 2 hours.

The overtopping analysis of this dam yielded the following values.

1) 1.9 feet

2) 14 hours

Therefore, dam failure during the above 1/2 PMF conditions is likely to occur.

To assess the impact of the dam failure on the downstream area, the 1/2 PMF was routed downstream to the Oneida Dam. The results of this flood routing indicated that the extent of overtopping of Oneida Dam would be increased significantly in the event of a failure of the Boydstown Dam by overtopping. In addition to an increase in the maximum water surface elevation of the Oneida Reservoir, the peak discharge would arrive at the Oneida Dam much sooner than if Boydstown Dam had not failed. According to a Phase I Inspection Report prepared by GAI Consultants, Inc., September 1978, an overtopping failure of Oneida Dam would significantly increase the potential hazard to residents downstream from that hazard which would exist just prior to failure. The report also stated that the dam was capable of passing only 30 percent of the PMF and that overtopping of the dam is expected to cause failure of the embankment. Therefore, failure of the Boydstown Dam by overtopping would cause a significant increase in damages in the areas downstream from the dam compared to damages resulting from nonfailure of the dam.

Based on the above results, the spillway is classified as "seriously inadequate" according to the recommended criteria.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations

(1) Embankment - As discussed in Section 3, the field observations did not reveal any signs of distress which would affect the structural stability of the embankment, however, it must be pointed out that the dense vegetation on the embankment and the proximity of Lake Oneida to the toe of the embankment severely hampered the visual inspection. It is recommended that the owner clear the vegetation from the dam. The owner should then have a registered professional engineer experienced in inspection and evaluation of earth dams perform an inspection of the areas where the vegetation hindered the inspection. This additional inspection can be performed as a part of PennDER's requirement for annual inspections of this dam.

(2) Appurtenant Structures - The right spillway training wall at the entrance to the spillway raises concern as to the continued stability of this wall. It is considered that remedial work should be performed to prevent a potentially catastrophic occurrence during flood flows. This work could possibly be performed as a part of the recommendation to provide additional spillway capacity. A number of uncertainties exist in relation to the condition and safety of the outlet works associated with the dam. Therefore, it is recommended that these be inspected and evaluated by a registered professional engineer experienced in the design of hydraulic structures for earth dams.

b. Design and Construction Data - Given the age of the structure and the state-of-the-art at the time of the construction of the dam, it is doubtful that any structural stability analyses have been performed for this dam. In view of the history of satisfactory performance of the slopes and the fact that no indications of instability were observed during the field inspection, no further stability assessments are necessary for this Phase I Inspection Report. For this particular dam, it

should be pointed out that the vegetation on the dam hindered the inspectors and the reservoir was not at normal pool during the inspection. Should future inspections observe signs of distress which would affect the structural stability of the embankment, additional evaluations and possibly corrective measures may be necessary.

c. Operating Records - The records available consist of the reservoir levels in Boydstown Reservoir and Lake Oneida. Nothing in these records or the operating procedures indicates concern relative to the structural stability of the dam.

d. Post-Construction Changes - Numerous changes have been performed (see Section 2) to the dam. Most of these changes have hopefully improved the structural stability and safety of the structure. However, numerous uncertainties concerning these changes exist, (i.e., were the core walls keyed into the bedrock, were they keyed into the abutments, type of backfill used, how much of the original timber crib spillway is still remaining in the dam) thus making an assessment of their effects on the structural stability difficult.

e. Seismic Stability - The dam is located in Seismic Zone 1 on the "Seismic Zone Map of the Contiguous United States," Figure 1, page D-30, "Recommended Guidelines for Safety Inspections of Dams." This is a zone of very low seismic activity. Experience indicates that dams in this zone will have adequate stability under seismic loading conditions provided static stability conditions are satisfied and conventional safety margins exist. As indicated in paragraph 6.1.b., further assessment of the static stability is recommended. If the evaluation and subsequent recommendations provide sufficient static stability factors of safety, then the dam should have sufficient seismic stability.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety - Boydstown Dam is evaluated as a "High" hazard - "Small" size dam and should have a hydraulic capacity sufficient to pass the PMF. As presented in Section 5, the spillway and reservoir were determined to have a capacity of only 30 percent of the PMF. Based upon this analysis and others noted in Section 5, the spillway is considered "seriously inadequate."

As a result of the spillway analyses and observations, Boydstown Dam is classified as an "Unsafe" - "Non-emergency" dam.

The overall condition of the dam at the time of inspection was very poor. The upper half of the spillway is in a deteriorated condition such that if a large flood discharge were to pass through the spillway, significant damage to the spillway structure would occur. The crest width of the embankment (7 feet) is insufficient according to current standards. In addition, several other features of the dam do not meet current design standards, i.e., lack of internal drainage system, the absence of positive seepage cut-offs along the outlet and water supply pipes. During the visual inspection, seepage was observed along the right abutment toe. This seepage is not considered to adversely affect the structural stability at this time because of its presence being noted as early as 1915 and the fact that transportation of fine material was not occurring at the time of inspection. Historical data from a seepage weir in 1916 and 1917 indicates that the amount of flow is responsive to reservoir fluctuations above a base amount of seepage flow (probably from natural groundwater). Therefore, it is recommended that the seepage be observed in the future for increased flow and turbidity.

b. Adequacy of Information - Generally, the information available is adequate to make an overall assessment of the dam, however, information concerning numerous important features of the dam is superficial and based upon word of mouth. It is recommened that additional information concerning these features be investigated as discussed in paragraph 7.1.d.

and properly placed on engineering drawings for future reference.

c. Urgency - The owner should initiate without delay further investigation, as discussed in paragraph 7.1.d.

d. Necessity for Additional Data/Evaluation - The hydraulic/hydrologic analysis performed for this dam has indicated the need for additional spillway capacity. Since the owner has already had a detailed analysis of the spillway capacity performed in conjunction with Lake Oneida Dam located downstream, additional evaluation of the spillway capacity is not necessary. However, recommendations for reducing the overtopping potential for the dam should be developed and implemented.

The owner should have a qualified professional engineer experienced in the design of hydraulic structures for earth dams perform an evaluation of the outlet works for this dam. Information concerning the details of the outlet works should be placed on engineering drawings for future reference.

7.2 RECOMMENDATIONS/REMEDIAL MEASURES

It is recommended that the owner give consideration to reconstructing or breaching the dam as an alternate to performing necessary repairs to the structure. Reconstruction of the dam to meet current design standards would be one method of providing safety for the structure without an extreme amount of expense considering the relatively narrow valley width. If, however, the economics do not warrant proper repairs or reconstruction, then the reservoir should be drawndown and the dam breached. If the owner feels the dam and reservoir constitutes an important part of their overall water supply system, then the following items should be performed without delay. Items 1, 2, and 3 below should be designed by a qualified professional engineer experienced in the design of earth dams.

1) Recommendations for reducing the overtopping potential of the dam should be developed and implemented. (Raising the top of dam without reconstructing the upper half of the spillway would not be acceptable because the spillway in its present condition would not withstand any high velocity discharges.)

2) The outlet works should be evaluated and current type, size, and location recorded on engineering drawings for future reference. If any of the outlet pipes are not provided with upstream closure, then procedures should be developed for rapid closure at the upstream end in the event of a pipe rupture.

3) The upper half of the spillway should be reconstructed to provide continued stability of the spillway structure against high discharge flows. (As mentioned previously, this can be performed in conjunction with providing the necessary spillway capacity to reduce the overtopping potential of the dam.)

4) The dense vegetation on the dam should be cleared and replaced with well maintained grass.

5) Riprap or other types of erosion control should be placed on the upstream slope to protect against erosion.

6) Proper inspection and maintenance procedures should be developed and implemented. Periodic inspection of the seepage at the right abutment toe should be included as a part of the inspections. The quantity and turbidity of the seepage should be recorded to identify any changing conditions.

7) Access to the dam should be improved to enable personnel to provide surveillance during flood discharges from Boydstown Dam and high reservoir stages of Lake Oneida.

In addition, the emergency operation and warning system for Lake Oneida should be expanded to include around-the-clock surveillance of Boydstown Dam during periods of unusually heavy rain or in the event of an emergency at the dam.

PLATES

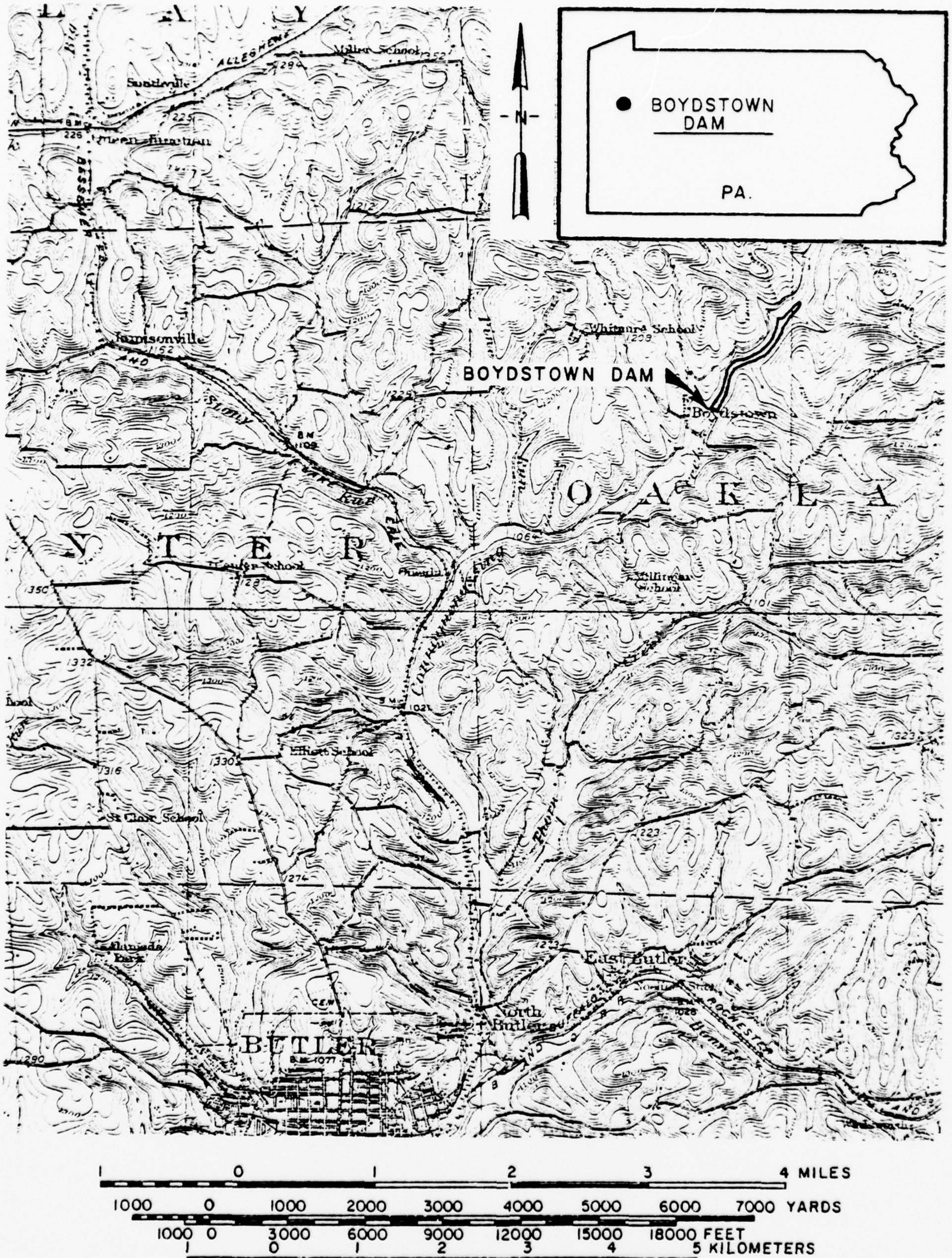
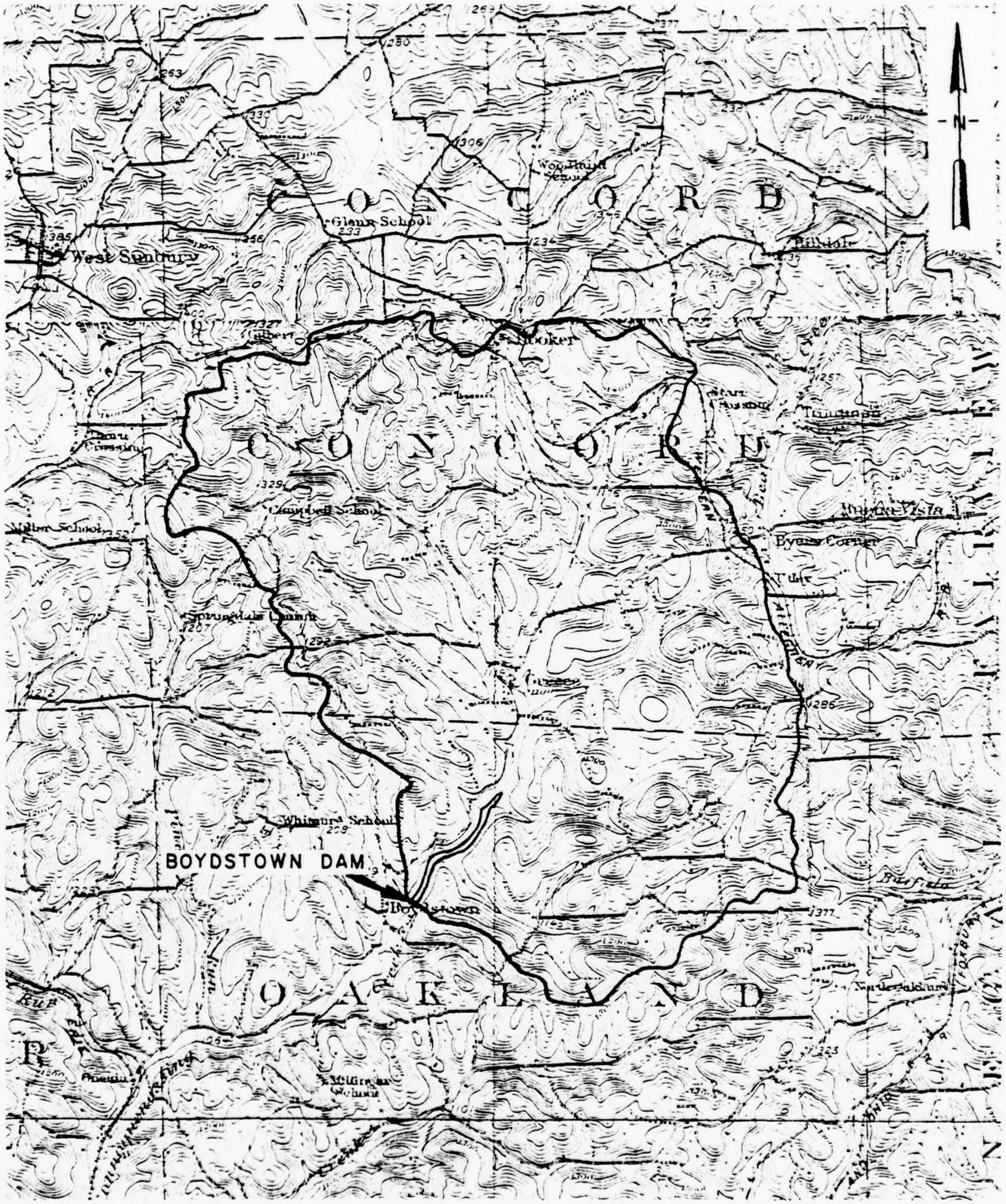


PLATE I LOCATION PLAN
BOYDSTOWN DAM



1 0 1 2 3 4 MILES
1000 0 1000 2000 3000 4000 5000 6000 7000 YARDS
1000 0 3000 6000 9000 12000 15000 18000 FEET
1 0 1 2 3 4 5 KILOMETERS

PLATE 2 WATERSHED MAP

BOYDSTOWN DAM

APPENDIX A

CHECK LIST - VISUAL INSPECTION AND FIELD SKETCH

Check List
Visual Inspection
Phase 1

Name of Dam Boydstown Dam County Butler State PA Coordinates Lat. N 40° 56.3'
NDI # PA 00270
PennDER # 10-1
Long. W 79° 50.6'

Date of Inspection 27 June 1979 Weather Sunny, Warm Temperature 85°F.

Pool Elevation at Time of Inspection 1065.6 ft. M.S.L. Tailwater at Time of Inspection 1055.1 ft. M.S.L.

Inspection Personnel:

Corps of Engineers,
Baltimore District:

Edward Hecker

Michael Baker, Jr., Inc.:

Dr. C. Y. Chen
Rodney E. Holderbaum
James G. Ulinski

Site Visit - 19 July 1979

Dr. C. Y. Chen
James G. Ulinski

Owner's Representative
Western Pennsylvania Water Company:

Mr. Al Reeder, Operations Manager
Butler District
William H. McAdams, Engineer
Raymond A. Dami

James G. Ulinski Recorder

CONCRETE/MASONRY DAMS - Not Applicable

Name of Dam: BOYDSTOWN DAM

NDI # PA 00270

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
LEAKAGE		
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS		
DRAINS		
WATER PASSAGES		
FOUNDATION		

CONCRETE/MASONRY DAMS - Not Applicable

Name of Dam: BOYDSTOWN DAM

NDI # PA 00270

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES		
STRUCTURAL CRACKING		
VERTICAL AND HORIZONTAL ALIGNMENT		
MONOLITH JOINTS		
CONSTRUCTION JOINTS		

EMBANKMENT

Name of Dam: BOYDSTOWN DAM

NDI # PA 00270

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None observed	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	Some wave erosion have occurred on the upstream slope.	The areas should be repaired and adequate riprap protection provided.
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	The dam was constructed in a curve making an assessment of the horizontal alignment difficult. The level survey performed during the visual inspection indicated 0.5 ft. difference from the left end of the dam to the right abutment.	
RIPRAP FAILURES	The riprap on the upstream face is disintegrated and missing in some places.	The upstream slope should be protected with an adequate amount of properly bedded riprap.

Name of Dam: BOYDSTOWN DAM
NDI # PA 00270

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
VEGETATION	At the time of the inspection, the dam was covered with thick vegetation making it difficult to observe all of the embankment.	The vegetation should be cleared and replaced with grass. The grass should then be cut frequently to facilitate future inspections.
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	No problems observed	
ANY NOTICEABLE SEEPAGE	Seepage was observed exiting from the right hillside approximately 50 ft. downstream from the embankment/right abutment junction. The clear flow was exiting at an estimated 2 g.p.m. A wet and marshy area is located downstream from the center of the dam. This area may be the result of tailwater from Lake Oneida.	It is recommended that the dam be examined again in the future under two differing conditions after the vegetation has been removed. 1) When the reservoir is at or above the spillway crest. 2) When Lake Oneida is low enough to observe the outlet pipe for Boydstown Dam.
STAFF GAGE AND RECORDER	None	
DRAINS	None	

OUTLET WORKS

Name of Dam: BOYDSTOWN DAM

NDI # PA 00270

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	The outlet conduit could not be observed at the time of the inspection because it was submerged.	Should be inspected when Lake Oneida is at low pool.
INTAKE STRUCTURE	Masonry stone circular tower with 3 gated inlets. Two of the gates to those inlets appear operational. The third or lowest valve stem is disconnected.	The valve stem should be repaired and a preventive maintenance schedule implemented.
OUTLET STRUCTURE	The outlet structure was submerged and could not be observed at the time of inspection.	Should be inspected when Lake Oneida is at low pool.
OUTLET CHANNEL	Lake Oneida is located immediately downstream from the dam. The outlet conduit discharges directly into Lake Oneida.	
EMERGENCY GATE	The gate located in the center of the intake tower which controls the outlet pipe flow appears to be operational. Additional valves located on the downstream end of the outlet pipe and the former water supply pipe are submerged and could not be observed. The 24 in. blow-off pipe is reportedly open into the reservoir.	

UNGATED SPILLWAY

Name of Dam: BOYDSTOWN DAM
NDI # PA 00270

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	The concrete weir is deteriorated and in poor condition. Former patchwork has chipped out.	Should repair the weir, possibly as a part of increasing the spillway capacity.
APPROACH CHANNEL	The shoreline, partially lined with deteriorated riprap, slopes toward the center of the reservoir.	Should be protected with additional riprap.
DISCHARGE CHANNEL	The upper half of the discharge channel is in a very deteriorated condition, including the right training wall which is tilted (several in.) into the spillway. The downstream half was replaced in 1954 and is in good condition.	The upper half of the discharge channel should be replaced or repaired.
BRIDGE AND PIERS	Not Applicable	

GATED SPILLWAY - Not Applicable

Name of Dam: BOYDSTOWN DAM

NDI # PA 00270

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL		
APPROACH CHANNEL		
DISCHARGE CHANNEL		
BRIDGE AND PIERS		
GATES AND OPERATION EQUIPMENT		

INSTRUMENTATION - Not Applicable

Name of Dam: BOYDSTOWN DAM

NDI # PA 00270

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS		
OBSERVATION WELLS		
WEIRS		
PIEZOMETERS		
OTHER		

RESERVOIR

Name of Dam: BOYDSTOWN DAM

NDI # PA 00270

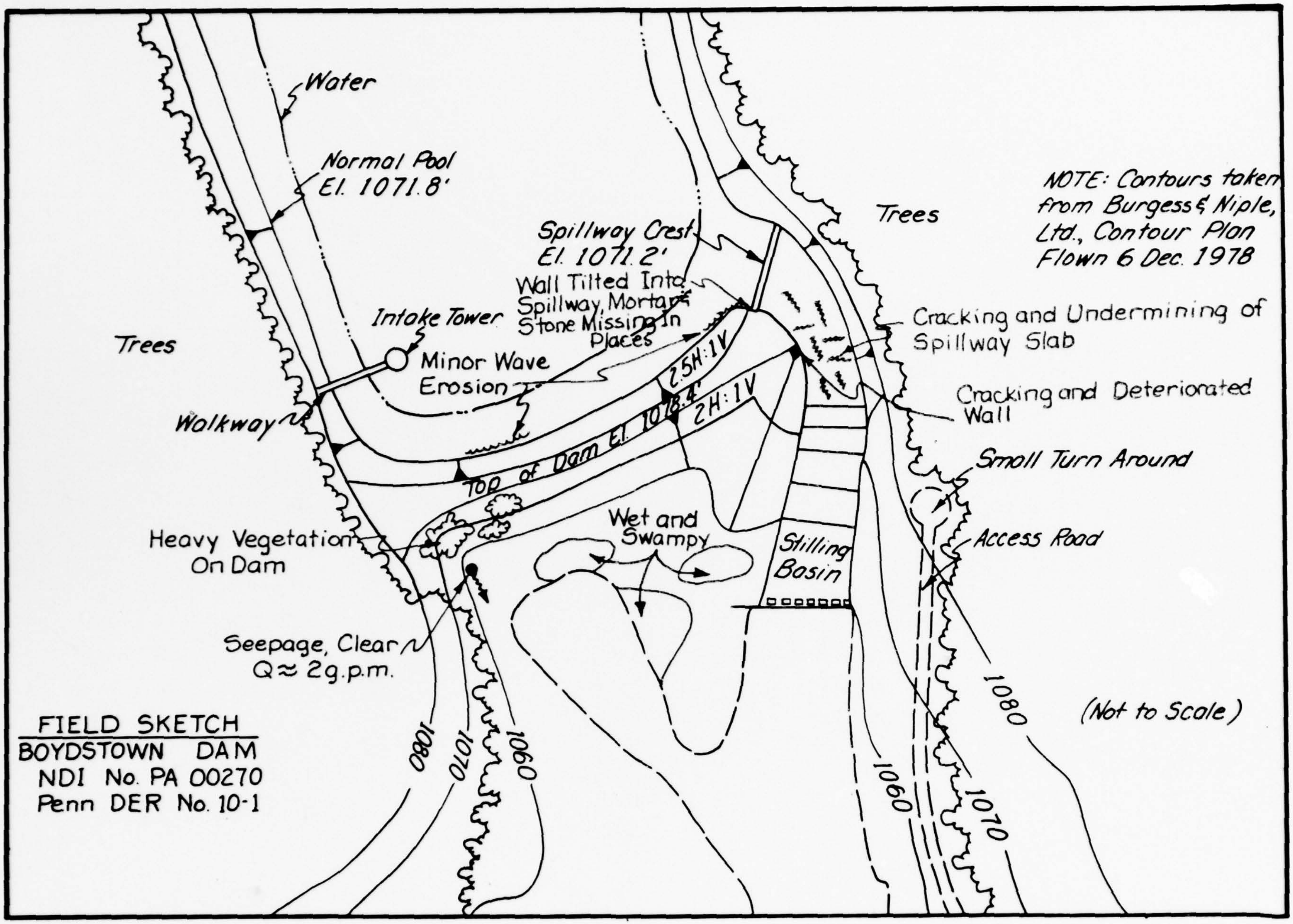
VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	The slopes adjacent to the reservoir were well vegetated and appeared stable.	
SEDIMENTATION	The amount of sedimentation in the reservoir is unknown.	

DOWNSTREAM CHANNEL

Name of Dam: BOYDSTOWN DAM

NDI # PA 00270

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Lake Oneida is located immediately downstream from the dam. A bridge crossing over Lake Oneida is located 1300 ft. downstream from Boydstown Dam.	
SLOPES	The stream channel slope downstream from Oneida Dam is mild, averaging 10-15 ft. per mi.	
APPROXIMATE NO. OF HOMES AND POPULATION	Lake Oneida Reservoir and Dam (NDI # PA 00272) are located downstream from Boydstown Dam. A Phase I Inspection Report for Lake Oneida Dam indicated 60-80 people downstream from Lake Oneida Dam and therefore placed the dam in the "High" hazard category.	



Water
Normal Pool
El. 1071.8'
Trees
Intake Tower
Minor Wave
Erosion
Walkway
Spillway Crest
El. 1071.2'
Wall Tilted Into Spillway, Mortar Stone Missing In Places
2.5H:1V
2H:1V
Top of Dam El. 1078.4'
Trees
NOTE: Contours taken from Burgess & Niple, Ltd., Contour Plan Flown 6 Dec. 1978
Cracking and Undermining of Spillway Slab
Cracking and Deteriorated Wall
Small Turn Around
Access Road
Heavy Vegetation On Dam
Wet and Swampy
Stilling Basin
Seepage, Clear
Q ≈ 2g.p.m.
1080
1070
1060
1060
1070
1080
(Not to Scale)
FIELD SKETCH
BOYDSTOWN DAM
NDI No. PA 00270
Penn DER No. 10-1

APPENDIX B

CHECK LIST - ENGINEERING DATA

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

Name of Dam: BOYDSTOWN DAM
NDI # PA 00270

ITEM	REMARKS
PLAN OF DAM	See the Field Sketch of this report.
REGIONAL VICINITY MAP	See Plate 1 of this report.
CONSTRUCTION HISTORY	See Section 2 of this report and the 1915 Water Supply Commission Report (available in PennDER File No. 10-1).
TYPICAL SECTIONS OF DAM	None available
HYDROLOGIC/HYDRAULIC DATA	No design data available
OUTLETS - PLAN, DETAILS, CONSTRAINTS, and DISCHARGE RATINGS	None available
RAINFALL/RESERVOIR RECORDS	Reservoir and rainfall data are available from 1954 to present.

Name of Dam: BOYDSTOWN DAM

NDI # PA 00270

ITEM	REMARKS
DESIGN REPORTS	None available
GEOLOGY REPORTS	None available. See Appendix E for the regional geology.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None available
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	None available
POST-CONSTRUCTION SURVEYS OF DAM	None available
BORROW SOURCES	No information available

Name of Dam: BOYDSTOWN DAM
NDI # PA 00270

ITEM	REMARKS
MONITORING SYSTEMS	None
MODIFICATIONS	Several modifications were performed in the early history of the dam. See Section 2 for as much of the detail that is available.
HIGH POOL RECORDS	Records available since 1954 indicate that in modern history of the dam, the highest pool was in 1954.
POST-CONSTRUCTION ENGINEERING STUDIES AND REPORTS	1915 Water Supply Commission Report on the dam, available in PennDER file. Currently a detailed evaluation of the spillway capacity is being performed in connection with Lake Oneida Dam.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	27 July 1897 - Overtopped - 100 foot section at right abutment washed out. 28 August 1903 - Overtopped - 130 foot section in the center of the embankment washed out. 1 October 1911 - Heavy spillway discharge, washed away downstream apron (information available in 1915 Water Supply Commission Report).
MAINTENANCE OPERATION RECORDS	None available

Name of Dam: BOYDSTOWN DAM
NDI # PA 00270

ITEM	REMARKS
SPILLWAY PLAN, SECTIONS, and DETAILS	No drawings showing the current configuration for the entire spillway is available.
OPERATING EQUIPMENT PLANS & DETAILS	No information available

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 13.6 sq.mi.

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 1071.2 ft. (236 ac.-ft.)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): 1078.4 ft. (514 ac.-ft.)

ELEVATION MAXIMUM DESIGN POOL: Unknown

ELEVATION TOP DAM: 1078.4 ft.

CREST: Spillway

- a. Elevation 1071.2 ft.
- b. Type Open channel
- c. Width 60 ft.
- d. Length Approximately 290 ft.
- e. Location Spillover Left abutment of dam
- f. Number and Type of Gates None

OUTLET WORKS:

- a. Type Stone masonry riser tower and outlet conduits
- b. Location At right end of embankment
- c. Entrance inverts Unknown
- d. Exit inverts Unknown
- e. Emergency draindown facilities 20 in. gated blow-off pipe

HYDROMETEOROLOGICAL GAGES: None

- a. Type
- b. Location
- c. Records

MAXIMUM NON-DAMAGING DISCHARGE Unknown

APPENDIX C

PHOTOGRAPHS

DETAILED PHOTOGRAPH DESCRIPTIONS

Overall View of Dam
- Upper Photo - Overall View of Dam from Left Abutment
- Lower Photo - Overall View of Downstream Portion of Dam from Left Abutment

Photo 1 - View of Spillway Looking Downstream

Photo 2 - View Looking Upstream at Crest of Spillway

Photo 3 - View Looking Downstream at Spillway Discharge Channel and Stilling Basin

Photo 4 - View Looking Upstream at Reconstructed Section of Spillway Discharge Channel

Photo 5 - View Looking Upstream at Intake Tower

Photo 6 - View Looking Downstream of Intake Tower and Upstream Slope of Embankment

Photo 7 - View Looking Downstream from Crest of Embankment (Note: Tailwater level is controlled by the level of Lake Oneida.)

Photo 8 - View of the Location of the Submerged Outlet Pipe

Photo 9 - Close-up View of Cracking and Loss of Material Beneath Spillway Slab

Photo 10 - Close-up View of Right Training Wall at the Entrance to Spillway Channel

Photo 11 - View of Seepage from Right Abutment Toe Area

Photo 12 - Close-up View of Right Abutment Toe Area (Note: Seepage is located near fragmented sandstone.)

Note: Photographs 1-10 were taken on 27 June 1979.
Photographs 11 and 12 were taken on 19 July 1979.

BOYDSTOWN DAM

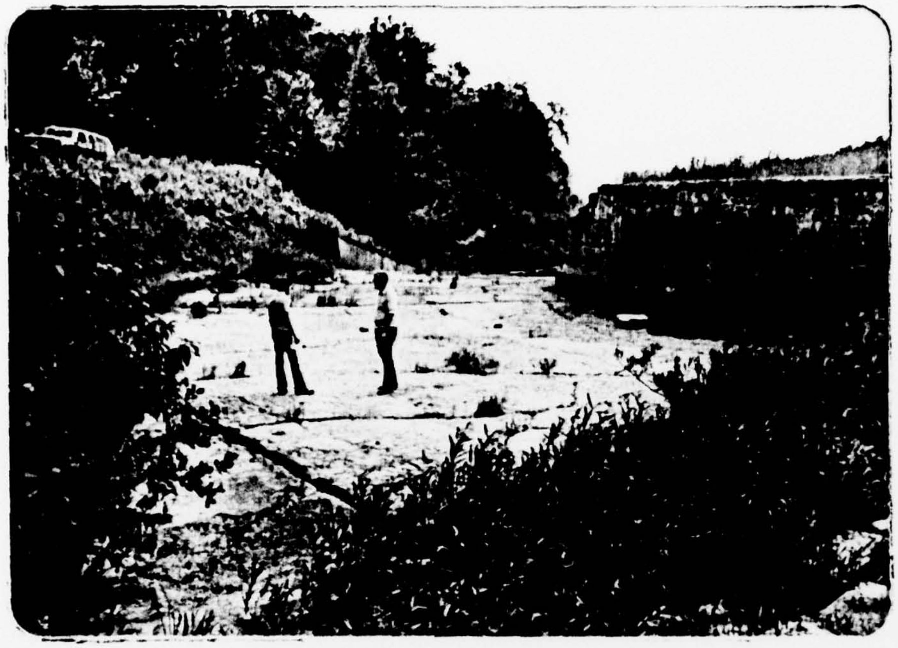


PHOTO 1. View of Spillway Looking Downstream

PHOTO 2. View Looking Upstream at Crest of Spillway

BOYDSTOWN DAM

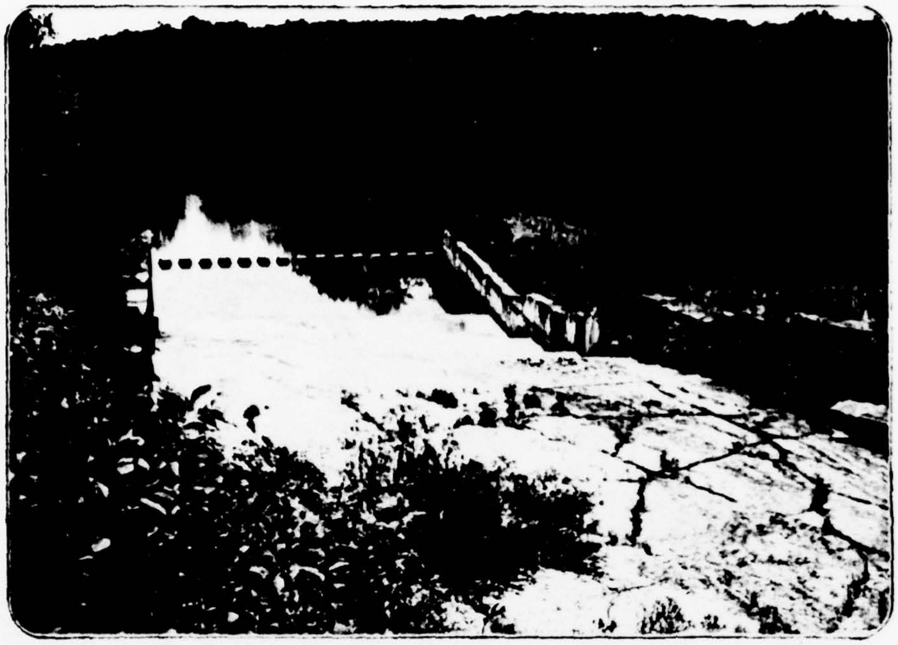


PHOTO 3. View Looking Downstream at Spillway Discharge Channel and Stilling Basin

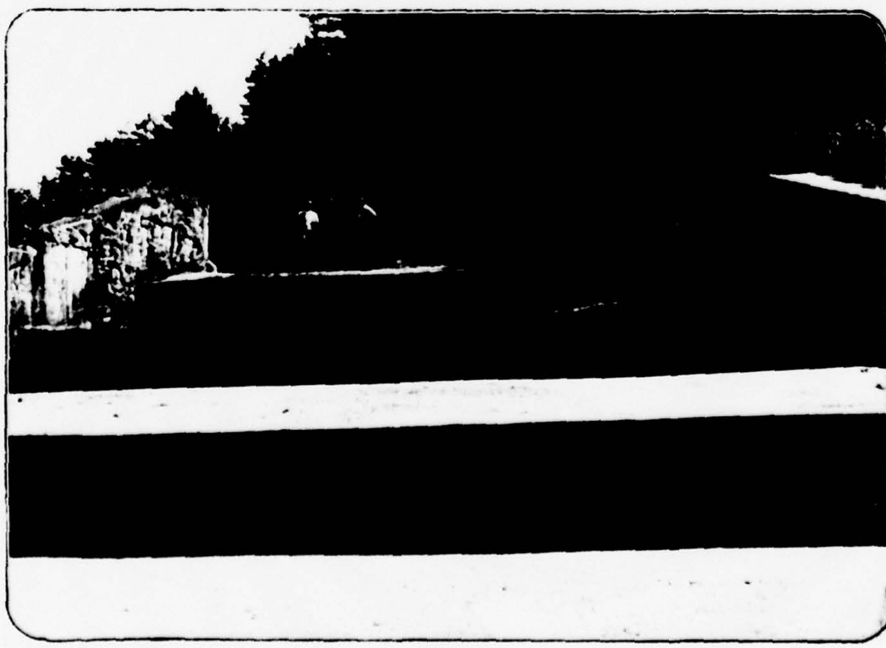


PHOTO 4. View Looking Upstream at Reconstructed Section of Spillway Discharge Channel

BOYDSTOWN DAM

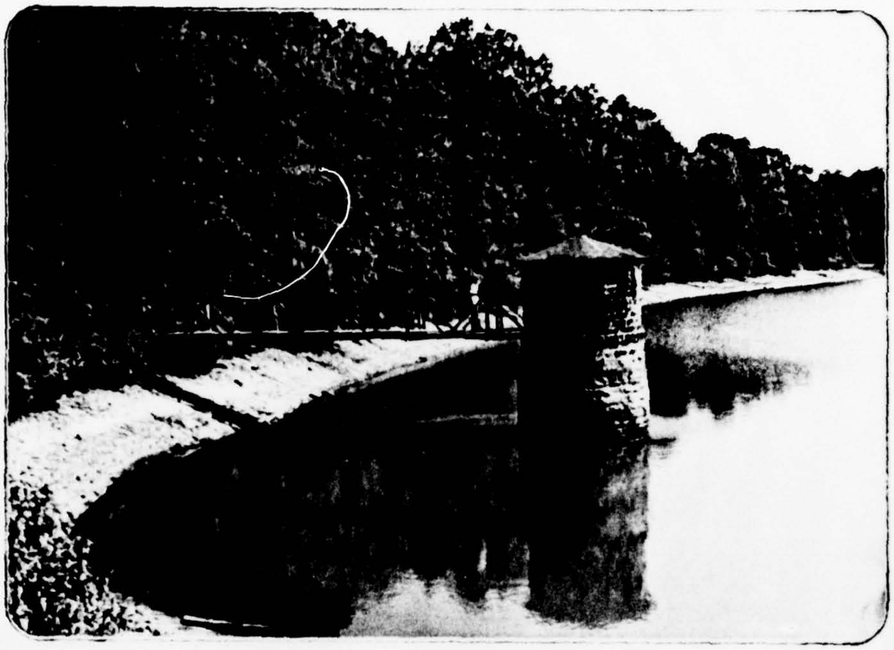


PHOTO 5. View Looking Upstream at Intake Tower

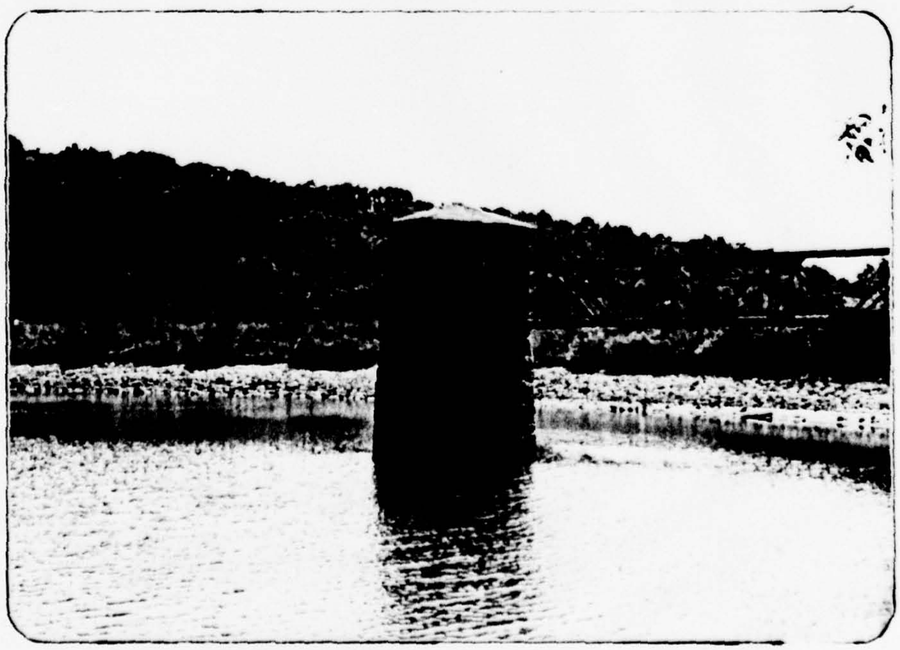


PHOTO 6. View Looking Downstream at Intake Tower and Upstream Slope of Embankment

BOYDSTOWN DAM

PHOTO 7. View Looking Downstream from Crest of Embankment
(Note: Tailwater level is controlled by the level of Lake Oneida.)

PHOTO 8. View of the Location of the Submerged Outlet Pipe

BOYDSTOWN DAM

PHOTO 9. Close-up View of Cracking and Loss of Material Beneath Spillway Slab

PHOTO 10. Close-up View of Right Training Wall at the Entrance to Spillway Channel

BOYDSTOWN DAM

PHOTO 11. View of Seepage from Right Abutment Toe Area

PHOTO 12. CLose-up of Right Abutment Toe Area
(Note: Seepage is located near fragmented sandstone.)

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject: Boydstown Dam
Hydrology and Hydraulics

S.O. No. ______
Sheet No. ______ of ______
Drawing No. ______

Computed by ______ Checked by ______ Date ______

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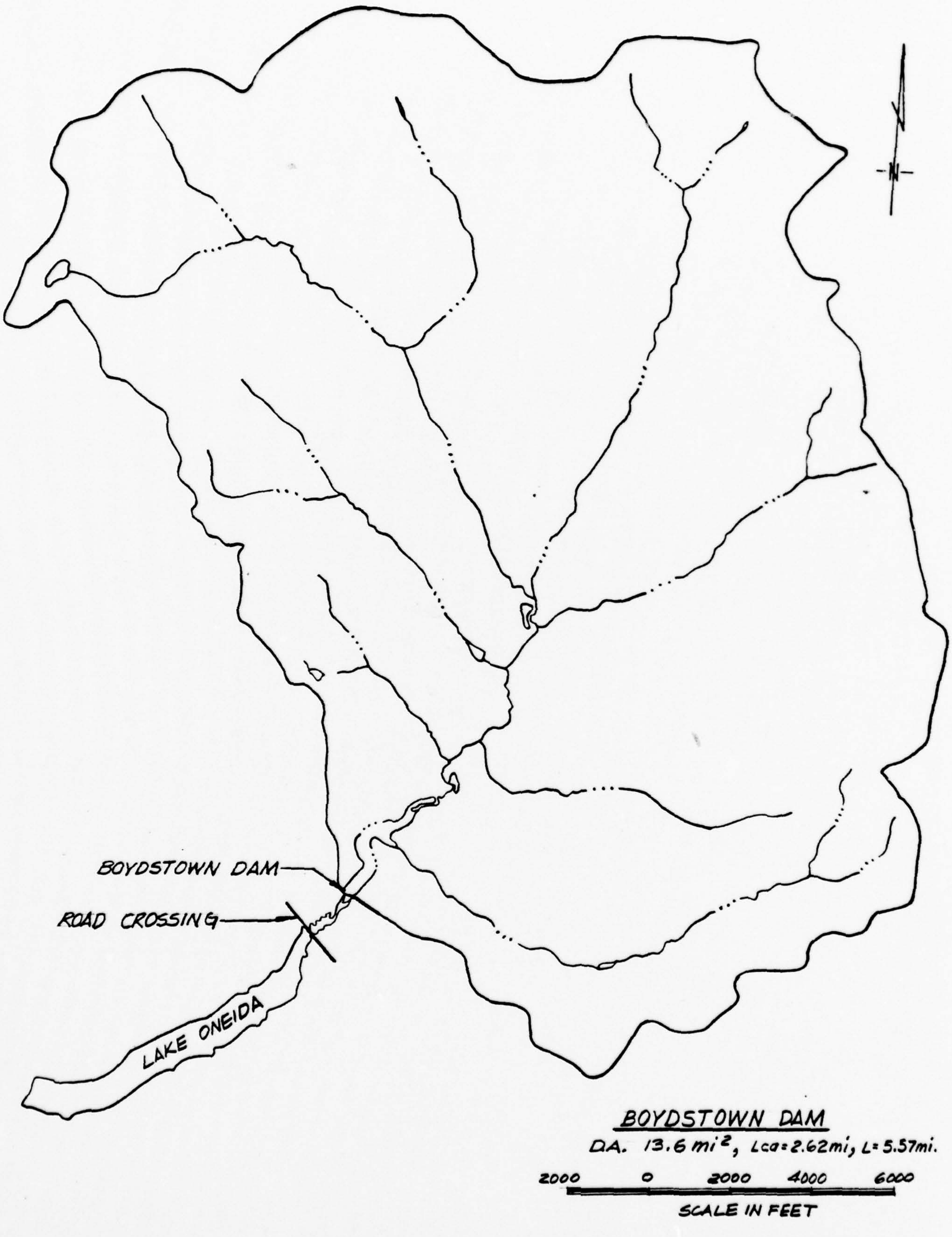


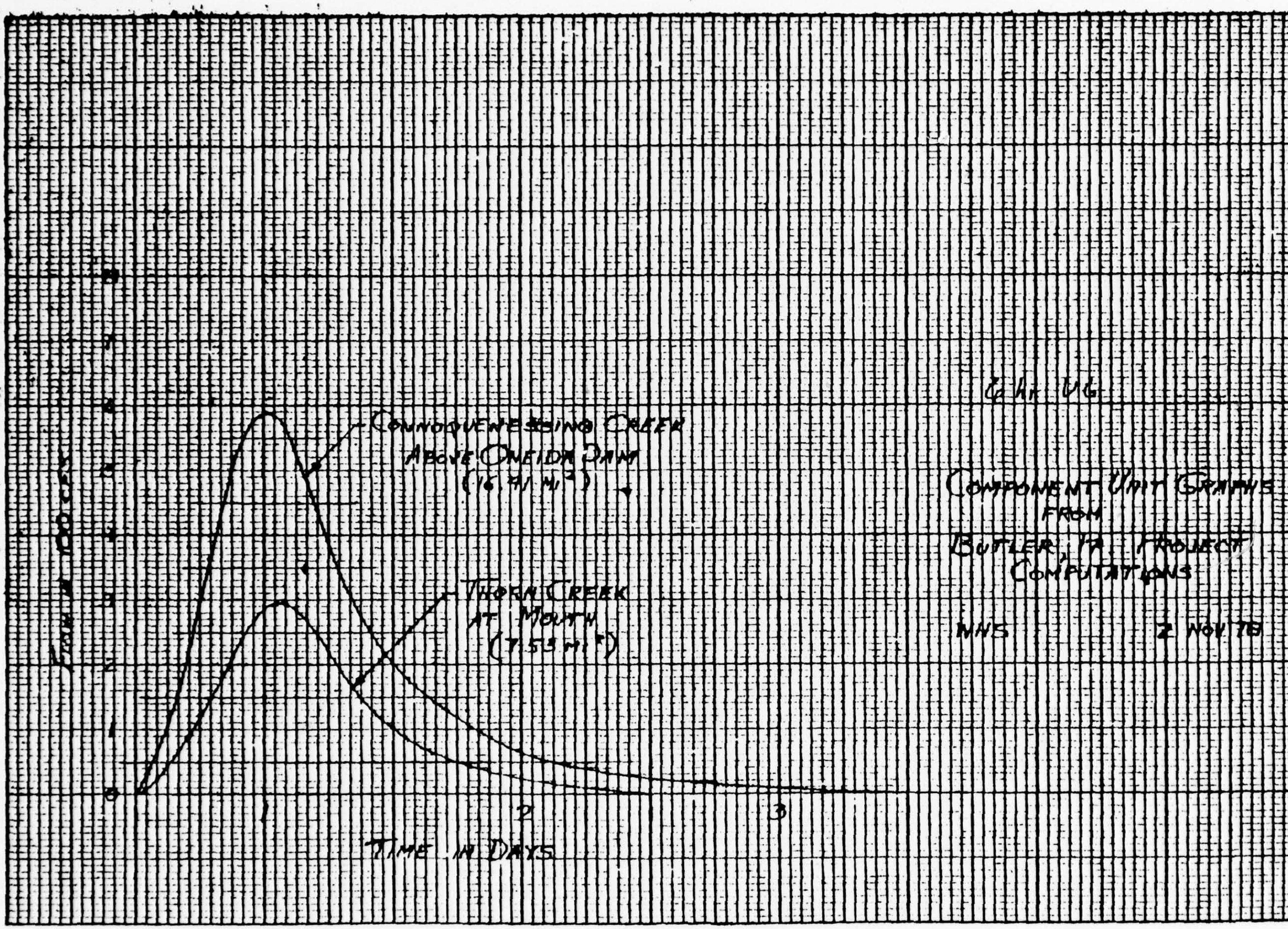
BOYDSTOWN DAM

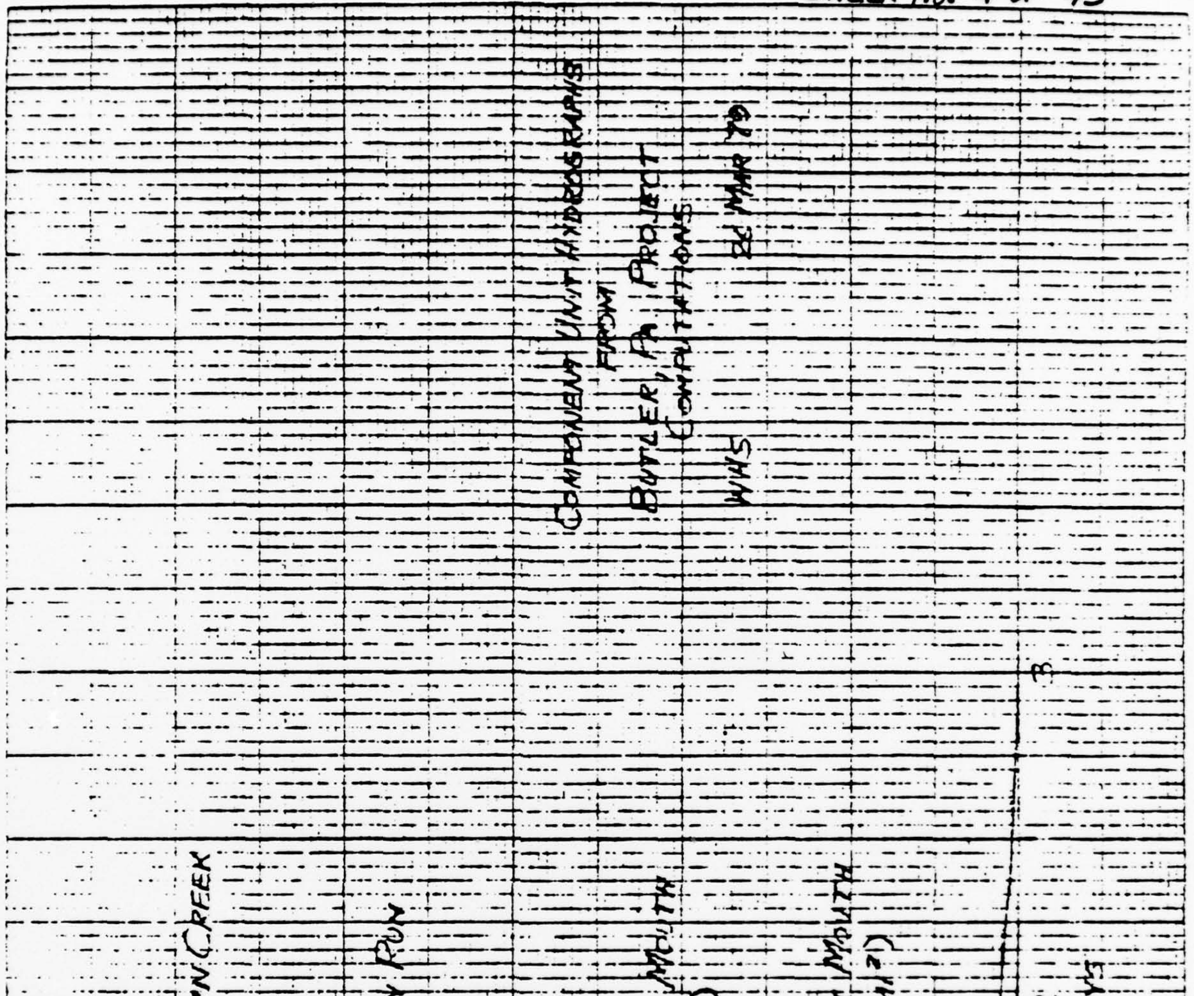
D.A. 13.6 mi^2, Lca=2.62mi, L=5.57mi.

List of Enclosures

Unit Hydrographs	2 sheets
Synopsis of FLOOD ROUTING RESULTS	
Text	4 sheets
PLAN Lake Oneida Dam	1 sheet
PLAN Boydstown Dam	1 sheet
Lake Oneida Dam Rating Curves	1 sheet
Boydstown Reservoir Rating Curves	1 sheet
Boydstown Reservoir Tailwater Rating	1 sheet
Boydstown Dam Storage & Area vs. Elevation	1 sheet
Synopsis of FLOOD ROUTING RESULTS - SUPPLEMENT	
Text	4 sheets
Regional Clark Parameters Plot	1 sheet
Inflow Outflow Hydrograph Plots	2 sheets
Boydstown Reservoir Storage Curve dated October 18, 1943	1 sheet
Selected HEC-1-DAM Computer Output	6 sheets

K+E 12 x 20 TO THE INCH 46 1073
7 X 10 INCHES
KEUFFEL & ESSER CO.




LOCAL FLOWS
STONY RUN TO THORN CREEK (8.12 MI²)
PINE RUN TO STONY RUN (0.46 MI²)
TRIBUTARY FLOWS
STONY RUN AT MOUTH (8.93 MI²)
PINE RUN AT MOUTH (3.72 MI²)
FLOW IN 100 CFS
FLOW IN 100 CFS
TIME IN DAYS
COMPONENT UNIT HYDROGRAPHS FROM BUTLER, PA. PROJECT COMPUTATIONS
WHS 26 MAR 79

Burgess & Niple, Limited
February 19, 1979

LAKE ONEIDA DAM

Synopsis of
FLOOD ROUTING RESULTS

The total drainage area at Lake Oneida Dam is 16.41 square miles, while the drainage area at the upstream Boydstown Dam is 13.58 square miles. Probable maximum precipitation for the total drainage basin was derived from Hydrometeorological Report No. 51, "Probable Maximum Precipitation Estimates, United States East of the 105th Meridian", prepared by the National Weather Service in June, 1978. Appropriate precipitation losses for the basin were determined from charts provided by Pittsburgh District, Corps of Engineers. The resulting total rainfall and runoff for a 72 hour probable maximum storm were 29.4 and 26.2 inches, respectively. The similar values computed for a storm of one-half the probable maximum were 14.7 and 12.0 inches, respectively.

Runoff hydrographs from the watershed were computed by the unit hydrograph method. The Pittsburgh District Corps of Engineers supplied a six hour duration unit hydrograph for Connoquenessing Creek at Oneida Dam which they had developed for a previous study. This unit hydrograph was transformed to Boydstown Dam and also to the area between Boydstown and Oneida Dams. The transformation was done using a procedure developed by Gert Aron and Arthur Miller at Pennsylvania State University and presented in the American Water Resources Association Bulletin of April, 1978, under the title of "Adaptation of Flood Peaks and Design Hydrographs from Gaged to Nearby Ungaged Watersheds". In order to provide better definition to the flood hydrographs, one hour duration unit hydrographs were then derived from the six hour duration unit hydrograph by the S-curve method. Finally, the one hour duration unit hydrograph for the area between the dams was proportioned into unit hydrographs representing runoff from the following subareas:

from Boydstown Dam to the road crossing of Lake Oneida, and from the road crossing to Oneida Dam. This final step was done in order to perform flood routing computations through the total stream hydrologic system.

Elevation versus storage data were derived from the two-foot contour interval topographic maps of the reservoirs and total stream systems that were flown for this study. Elevation versus discharge data for flow over the spillways, and also over the dams, were determined by using the HEC-2, Water Surface Profiles, computer program. This method was used in order to reflect any influence of tailwater submergence on the discharge ratings. The spillway capacity at Boydstown Dam was found to be 3,100 cubic feet per second at the top of dam, Elevation 1078.4 and at Oneida Dam 3,900 cubic feet per second at the top of dam, Elevation 1063.7. The HEC-2 program was also used to determine the discharge rating data for the road crossing of Lake Oneida.

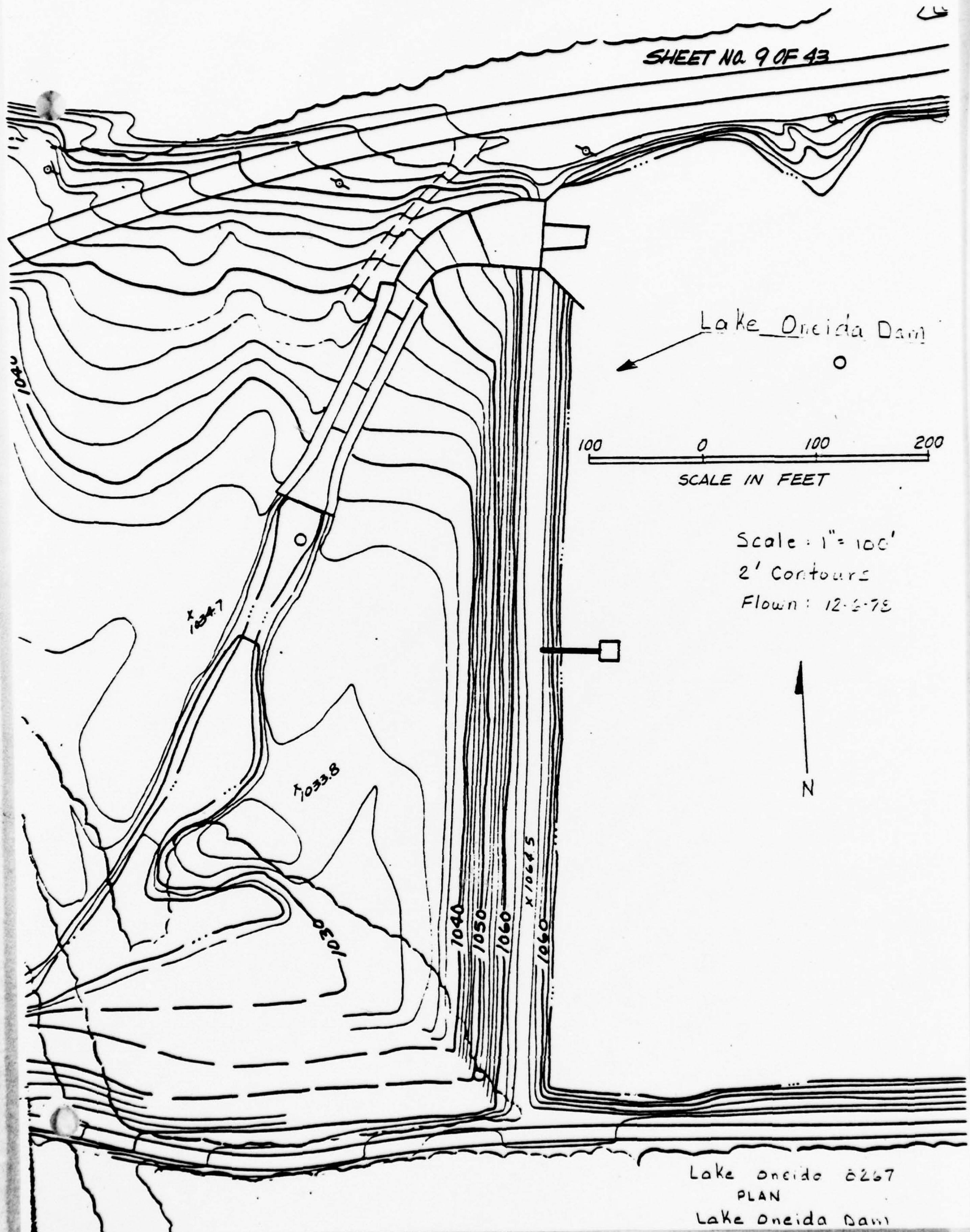
Flood runoff hydrograph routing computations were performed using the HEC-1, Flood Hydrograph Package (Dam Safety version), computer program. The peak discharge of the inflow hydrograph for the probable maximum flood (PMF) at Boydstown Dam was found to be 11,760 cubic feet per second and for the one-half PMF it was 5,670 cubic feet per second. The same peak inflow discharges at Oneida Dam were found to be 14,430 and 6,940 cubic feet per second, respectively. Assuming that flow could occur over dams without their failing, the maximum water surface elevations for the PMF and one-half PMF at Boydstown Dam were 1082.2 and 1080.2, while at Oneida Dam the similar elevations were 1066.6 and 1065.1. Therefore, both dams would be overtopped by both the PMF and the one-half PMF.

An analysis to determine the height of dams necessary to prevent overtopping while employing the existing spillways was performed by considering flow over the spillways only. The resulting PMF maximum water surface elevations at Boydstown and Oneida Dams were 1089.9 and

1074.4, respectively. Thus, Boydstown Dam would have to be raised 11.5 feet and Oneida Dam 10.7 feet to contain the PMF. The resulting one-half PMF maximum water surface elevations at Boydstown and Oneida Dams were 1082.0 and 1066.3, respectively. Thus, Boydstown Dam would have to be raised 3.6 feet and Oneida Dam 2.6 feet to contain the one-half PMF.

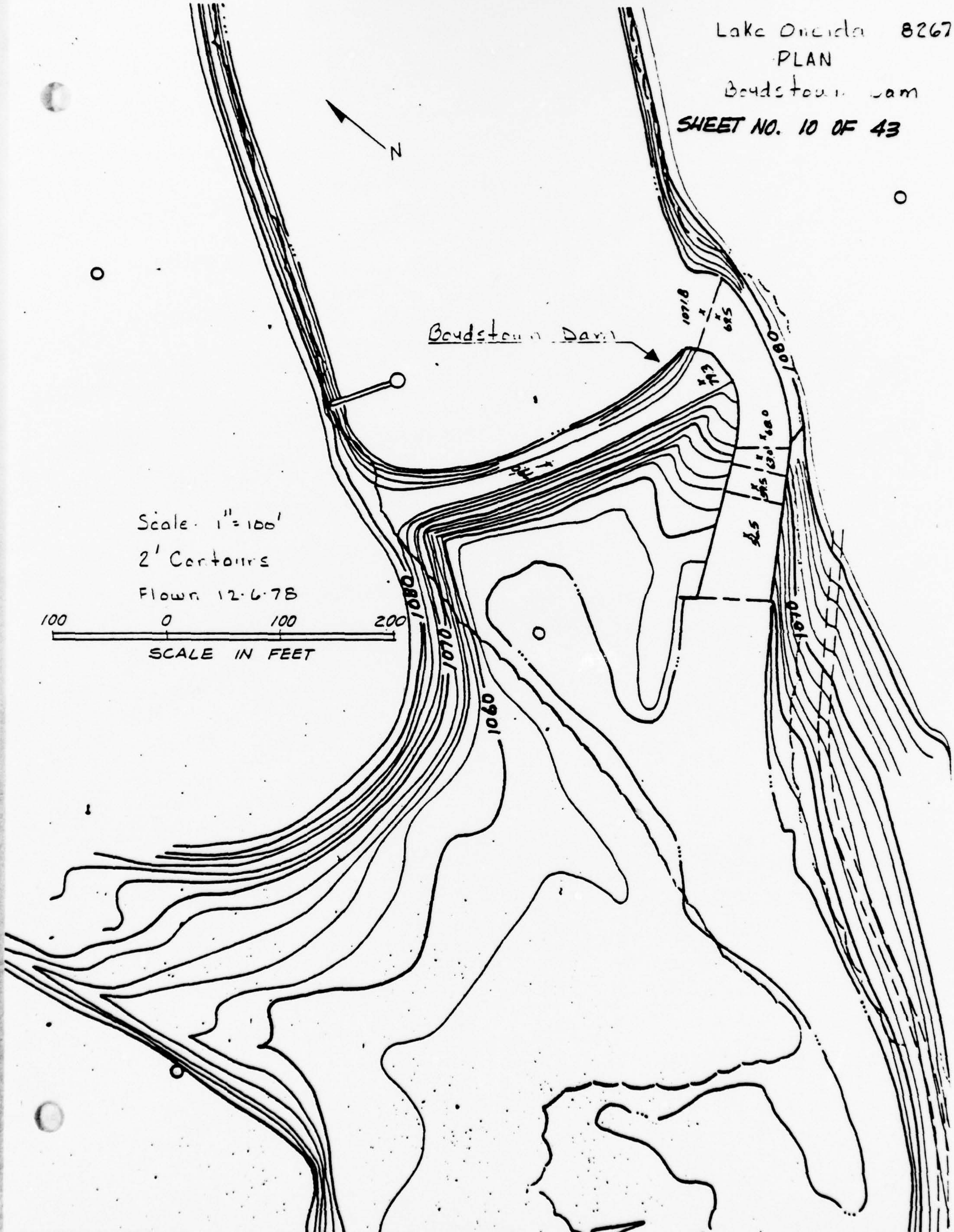
An alternative analysis to determine the height of Oneida Dam necessary to prevent overtopping while employing its existing spillway was performed by considering flow over its spillway only, but allowing flow at Boydstown Dam to be over the spillway and dam. The resulting PMF and one-half PMF maximum water surface elevations at Oneida Dam were 1074.6 and 1066.3, respectively. For the PMF, this is only 0.2 foot higher than if Boydstown Dam was also raised to contain the flow to its existing spillway. For the one-half PMF, the amount Oneida Dam would have to be raised remains the same whether or not Boydstown Dam is also raised. This alternative analysis does not reflect what could happen if Boydstown Dam were to fail when it is overtopped during the PMF or one-half PMF.

	Lake Oneida (Oneida Dam)		Boydstown Dam	
	PMF	1/2 PMF	PMF	1/2 PMF
Peak Flow Inflow - cfs	14,430	6,940	11,760	5,670
Maximum Reservoir Stage Elevation	1,066.6	1,065.1	1,082.2	1,080.2
Peak Outflow - cfs	14,380	6,780	11,760	5,670
(1) through spillway	6,200	5,000	5,600	4,200
(2) over dam embankment	8,180	1,780	6,160	1,470
Depth of Overtopping - feet	2.9	1.4	3.8	1.8
Duration of Overtopping - hours	22	11	24	12

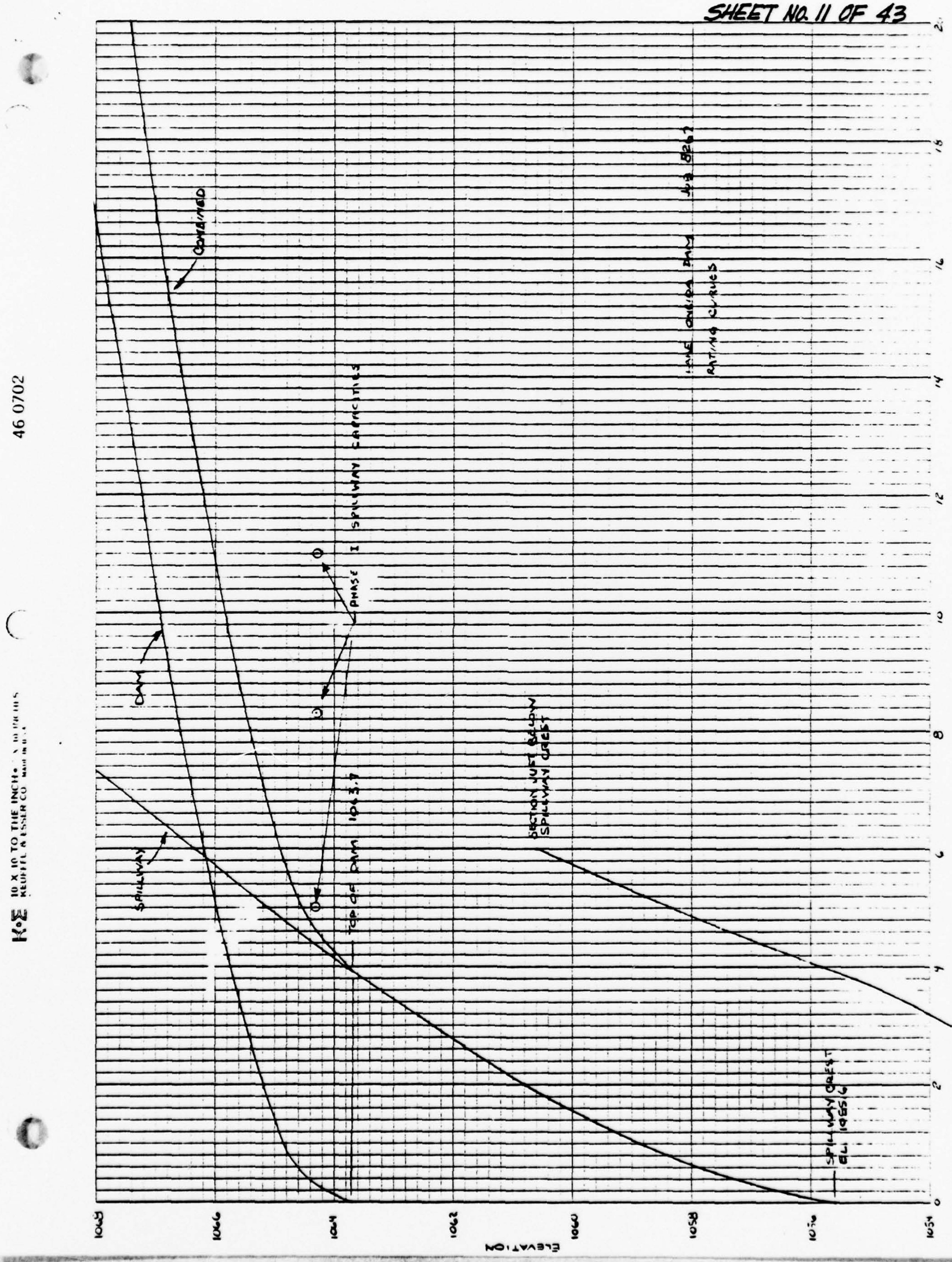


Lake Oneida 6267
PLAN
Lake Oneida Dam

Lake Oneida 8267
PLAN
Boydstown Dam
SHEET NO. 10 OF 43

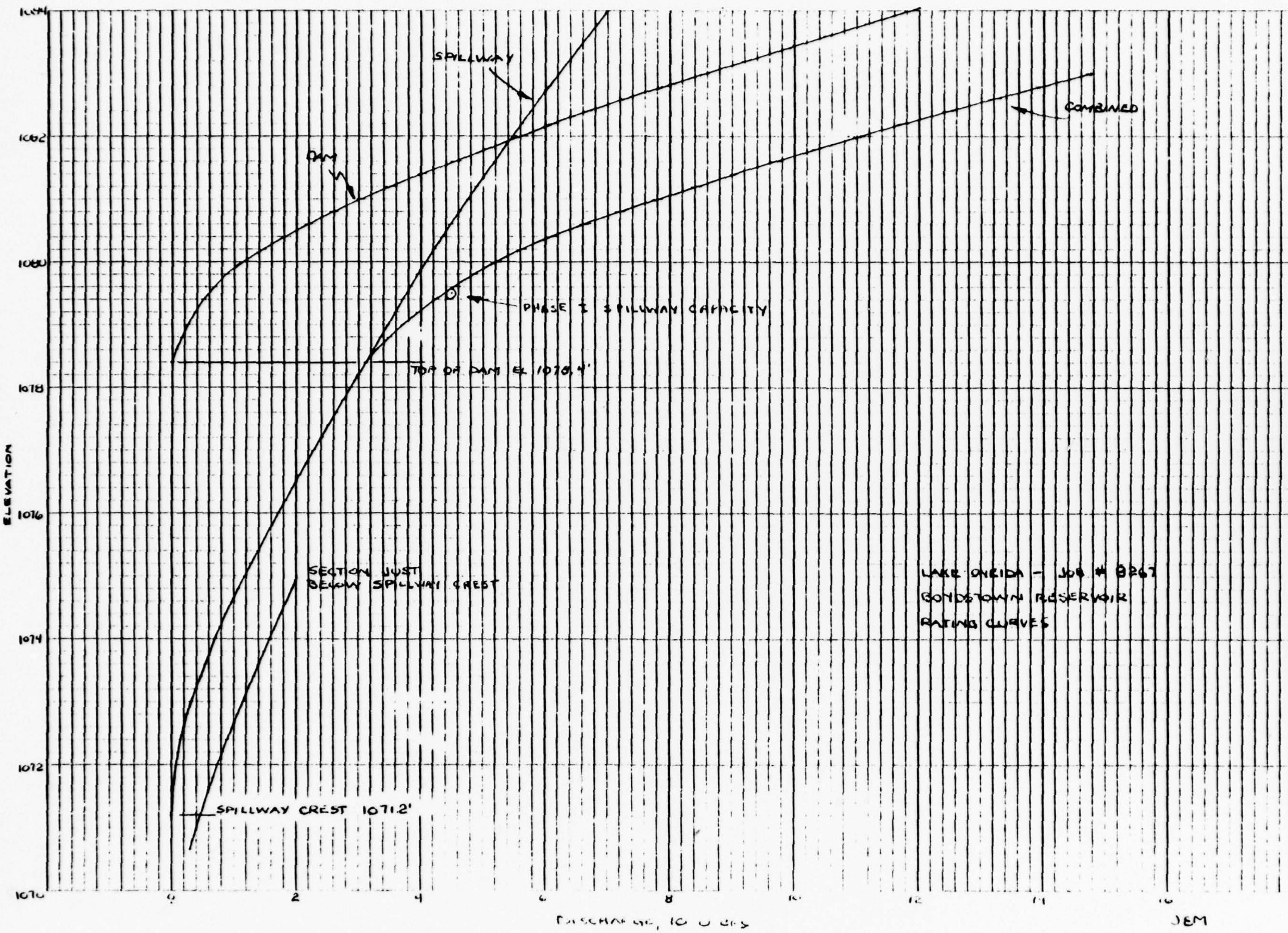


SHEET NO. 11 OF 43

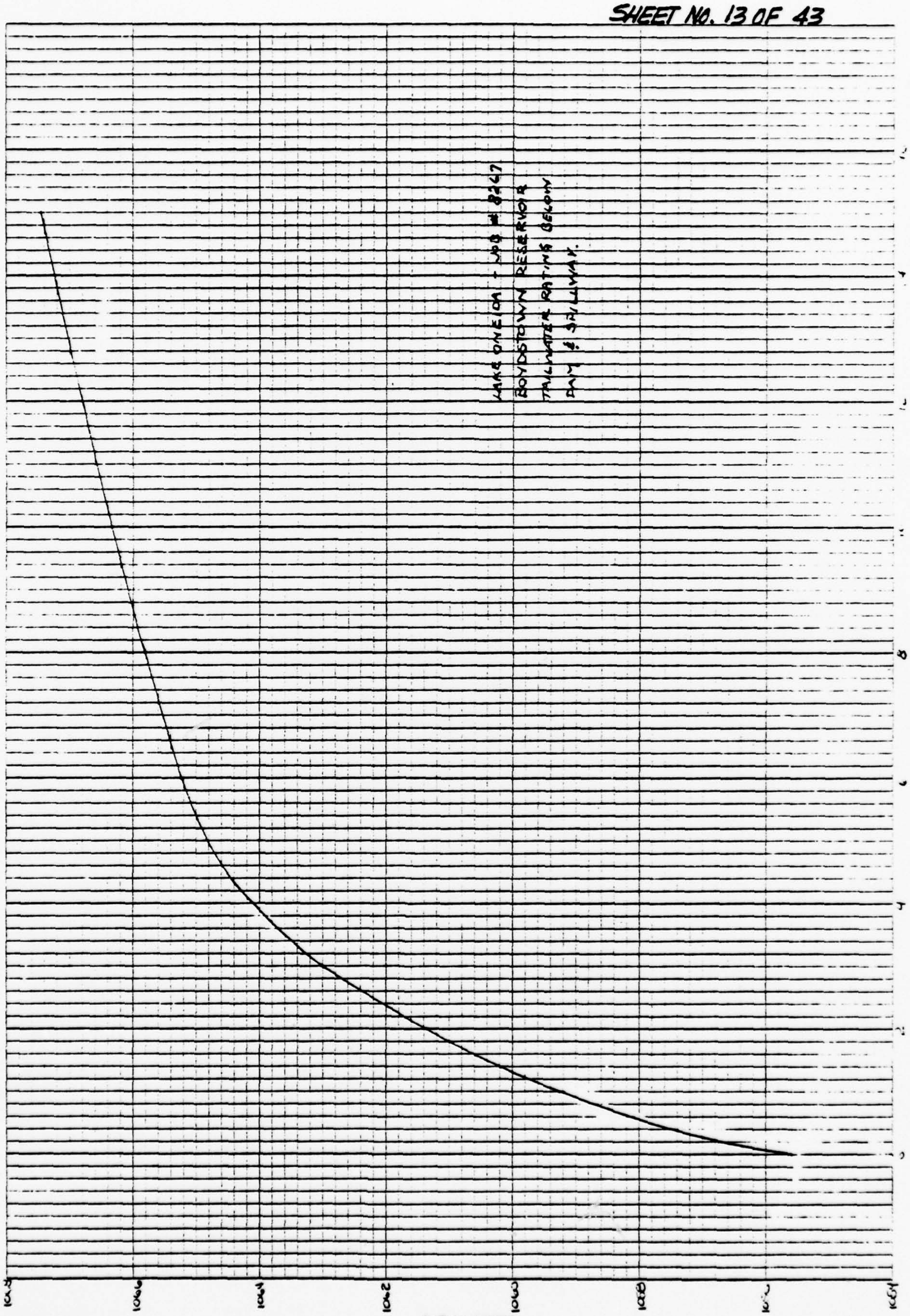


K&E 10 X 10 TO THE INCH KEUFFEL & ESSER CO.

46 0702



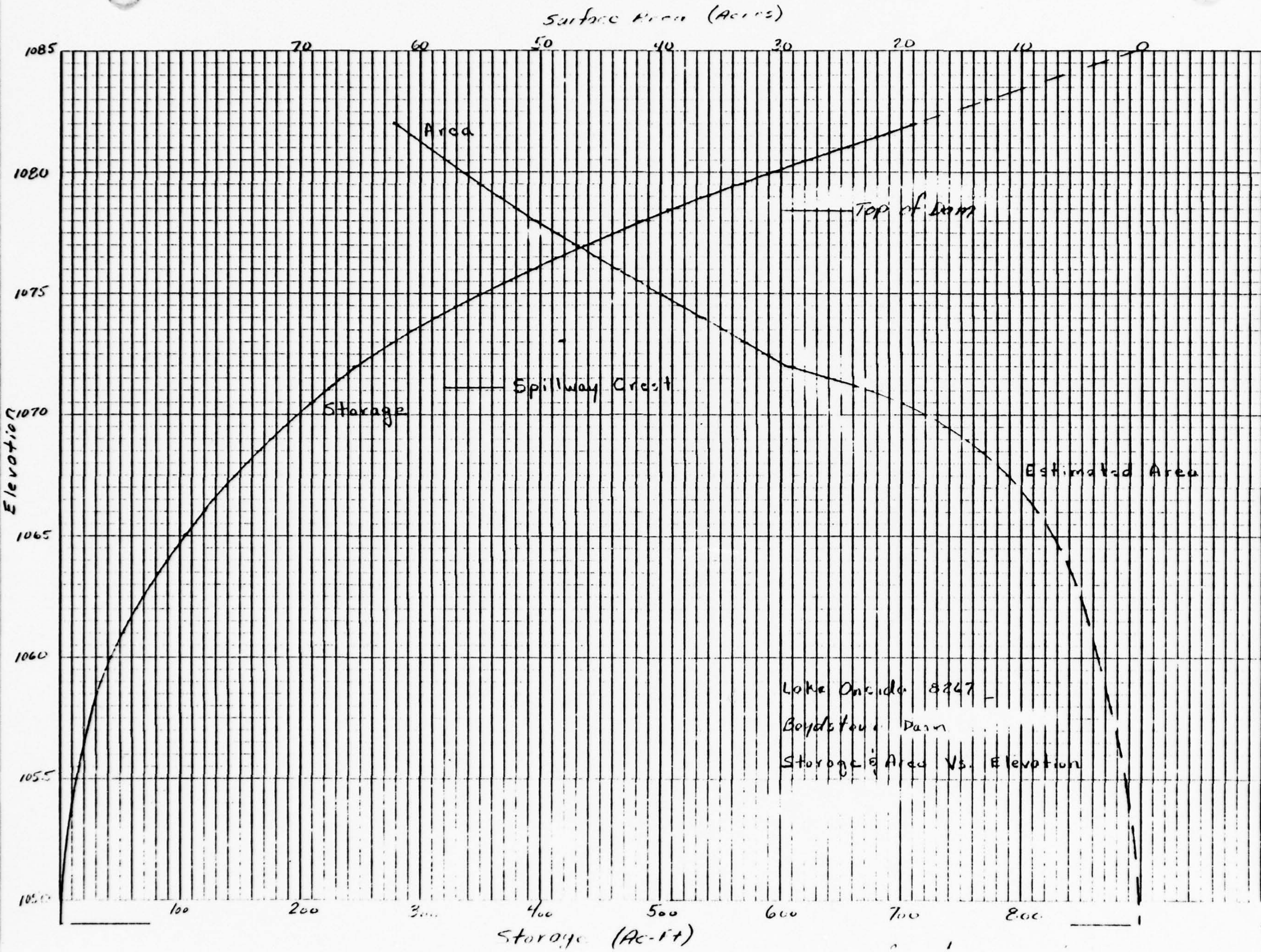
SHEET NO. 12 OF 43



2-19-79

46 0702

K+E 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.


Surface Area (Acres)
70
60
50
40
30
20
10
0
1085
1080
1075
1070
1065
1060
1055
1050
Elevation
Area
Top of Dam
Spillway Crest
Storage
Estimated Area
Lake Oneida 8247
Boydstown Dam
Storage & Area Vs. Elevation
100
200
300
400
500
600
700
800
Storage (Ac-Ft)

LAKE ONEIDA DAM

Synopsis of
FLOOD ROUTING RESULTS

SUPPLEMENT

Adjustments to flood routing computations were made subsequent to modifications in unit hydrograph derivations for the tributary subareas. Unit hydrograph analysis was revised using optimization routines of the HEC-1, Flood Hydrograph Package, computer program, and procedures suggested in the HEC-1 User's Manual to provide regional consistency. Only changes made to the previous flood hydrograph analysis are included in the following discussion.

Four unit hydrographs (six hour durations) in the vicinity of Lake Oneida Dam were developed for a previous study by the Pittsburgh District Corps of Engineers. Locations of these unit hydrographs and their drainage areas are given in Table 1.

Table 1

LOCATIONS AND DRAINAGE AREAS OF
SIX HOUR UNIT HYDROGRAPHS SUPPLIED

Location	Drainage Area (square miles)
Thorn Creek at Mouth	7.53
Connoquenessing Creek above Oneida Dam	16.41
Stony Run at Mouth	8.93
Pine Run at Mouth	3.72

One hour unit hydrographs were derived from the six hour unit hydrographs. These derivations provided best fit optimization without any predetermined restrictions and resulted in optimum Clark unit hydrograph coefficients. The computed times of concentration TC and storage coefficients R were combined into ratios, and the average

Note: This data supercedes that dated Feb. 19, 1979.

regional ratio of 0.53 for R/(TC+R) was determined. One hour unit hydrographs were redetermined from the original six hour unit hydrographs to give new TC and R values for each drainage area based on the regional ratio. The sums TC+R from the second optimization were correlated to the respective drainage areas (DA) for the locations in Table 1, providing equation 1:

$$TC+R = 11.84\ DA^{0.184} \qquad \text{(Eq. 1)}$$

Solving the average regional ratio equation for R and substituting the result into equation 1, equation 2 results giving the time of concentration in hours:

$$TC = 5.56\ DA^{0.184} \qquad \text{(Eq. 2)}$$

Clark times of concentration and storage coefficients for the various subareas in the flood routing system were then computed from equations 1 and 2 and were used for flood hydrograph computation.

Revised flood hydrograph routing computations were performed using Clark subarea TC and R values for unit hydrograph definition in the HEC-1, Flood Hydrograph Package (Dam Safety Version), computer program. The peak inflow at Boydstown Dam for the probable maximum flood (PMF) would be 12,180 cubic feet per second while that for the one-half PMF would 5,880 cubic feet per second. Corresponding inflows at Lake Oneida Dam would be 15,130 cubic feet per second and 7,240 cubic feet per second. Assuming that flow could occur over both dams without their failure, the maximum water surface elevations for the PMF and one-half PMF at Boydstown Dam would be 1,082.3 and 1,080.3 while at Lake Oneida Dam the elevations would be 1,066.7 and 1,065.2. The two dams would be overtopped by both the PMF and the one-half PMF. Table 2 summarizes the existing condition flood routing results.

Table 2

EXISTING CONDITION FLOOD ROUTING RESULTS

	Lake Oneida (Lake Oneida Dam)		Boydstown Dam	
	PMF	1/2 PMF	PMF	1/2 PMF
Peak Inflow (cfs)	15,130	7,240	12,180	5,880
Maximum Reservoir Elevation (feet)	1,066.7	1,065.2	1,082.3	1,080.3
Peak Outflow (cfs)	14,980	7,120	12,180	5,880
Through spillway	6,280	5,080	5,700	4,260
Over Dam Embankment	8,700	2,040	6,480	1,620
Depth of Overtopping (feet)	3.0	1.5	3.9	1.9
Duration of Overtopping (hours)	22	11	23	14

An analysis to determine the height of dams necessary to prevent overtopping while employing the existing spillways was performed by considering flow over the spillways only. The resulting PMF maximum water surface elevations at Boydstown and Lake Oneida Dams were 1,090.5 and 1,075.0 respectively. Thus, Boydstown Dam would have to be raised 12.1 feet and Lake Oneida Dam 11.3 feet to contain the PMF. The resulting one-half PMF maximum water surface elevations at Boydstown and Lake Oneida Dams were 1082.3 and 1066.6, respectively. Boydstown Dam would have to be raised 3.9 feet and Lake Oneida Dam 2.9 feet to contain the one-half PMF.

An alternative analysis to determine the height of Lake Oneida Dam necessary to prevent overtopping while employing its existing spillway was performed by considering flow over its spillway only, but allowing flow at Boydstown Dam over the spillway and dam. The resulting PMF and one-half PMF maximum water surface elevations at Lake Oneida Dam were 1,075.2 and 1,066.7, respectively. For the PMF, this is only 0.2 foot higher than if Boydstown Dam was also raised to contain the flow to its existing spillway. For the one-half PMF, the amount Lake Oneida Dam would have to be raised is 0.1 foot higher than if Boydstown Dam were also raised. This alternative analysis does not reflect what could happen if Boydstown Dam were to fail when it is overtopped during the PMF or one-half PMF.

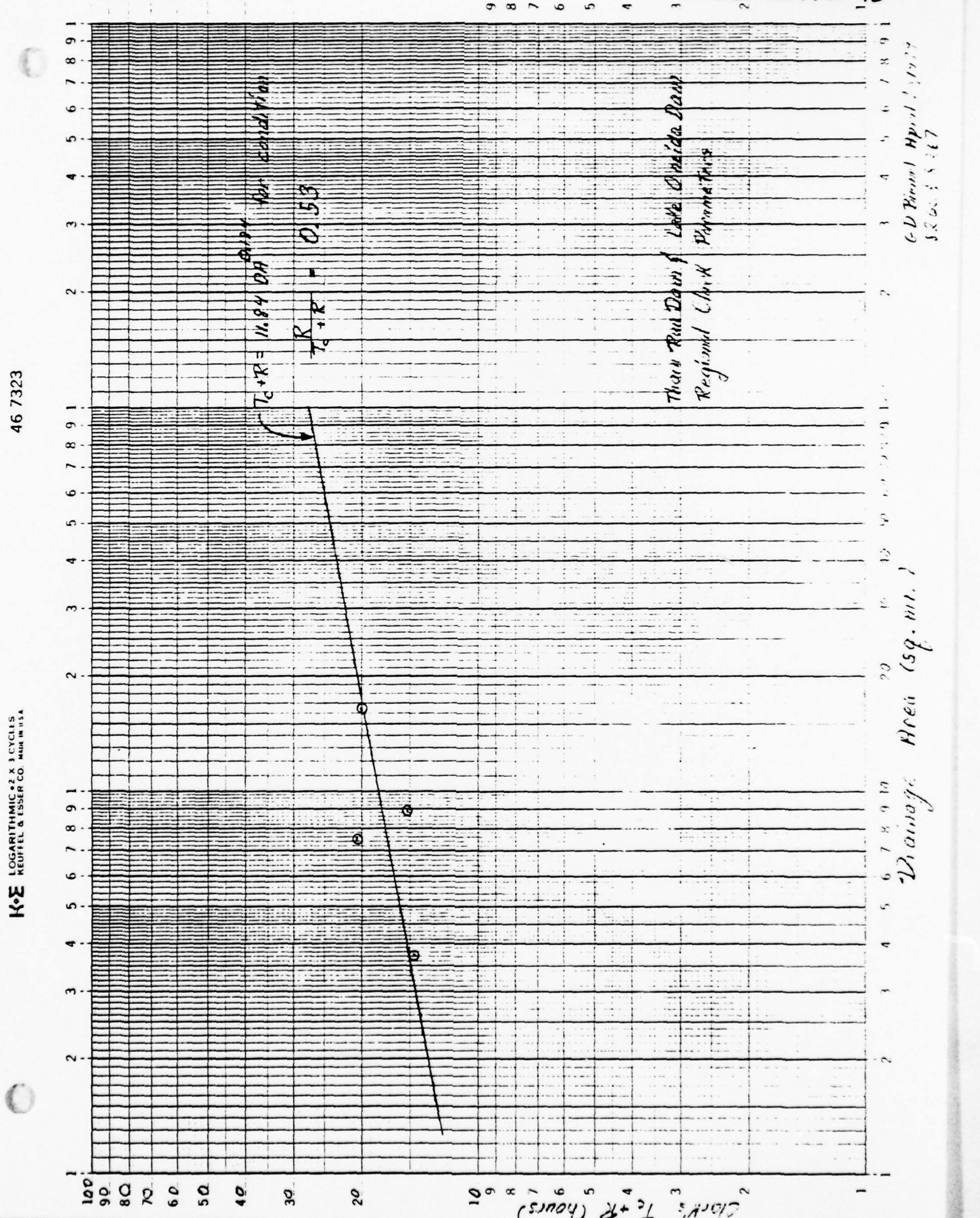
Table 3 compares the flood routing results from this revised analysis to the results from the previous analysis.

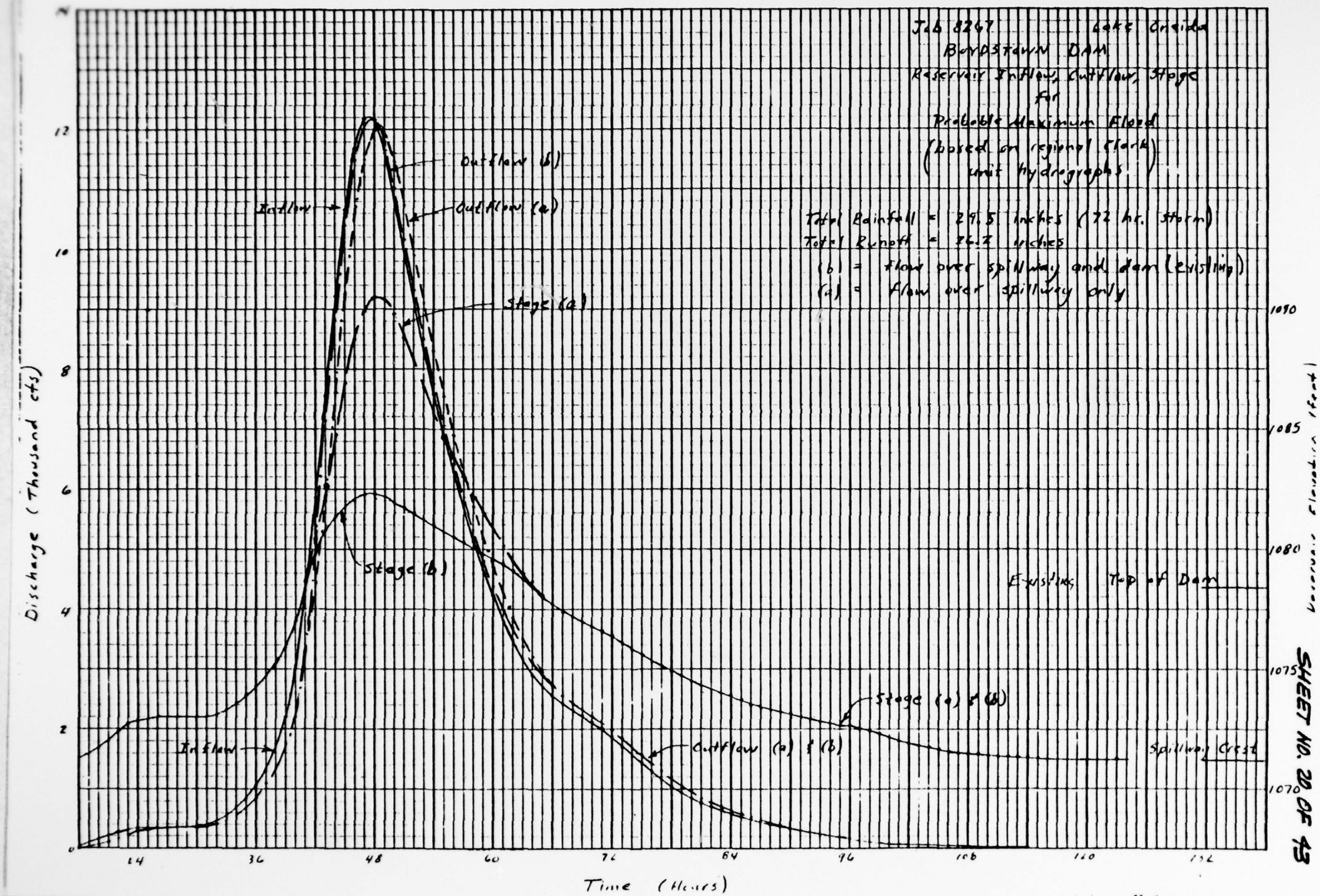
Table 3

COMPARISON OF FLOOD ROUTING RESULTS

	Lake Oneida (Lake Oneida Dam)		Boydstown Dam	
	PMF	1/2 PMF	PMF	1/2 PMF
Existing Peak Inflow (cfs)				
Revised	15,130	7,240	12,180	5,880
Previous	14,430	6,940	11,760	5,670
Change	700	300	420	210
Existing Stage (feet)				
Revised	1,066.7	1,065.2	1,082.3	1,080.3
Previous	1,066.6	1,065.1	1,082.2	1,080.2
Change	0.1	0.1	0.1	0.1
Plan A Stage (feet)(a)				
Revised	1,075.0	1,066.6	1,090.5	1,082.3
Previous	1,074.4	1,066.3	1,089.9	1,082.0
Change	0.6	0.3	0.6	0.3
Plan B Stage (feet)(b)				
Revised	1,075.2	1,066.7	1,082.3	1,080.3
Previous	1,074.6	1,066.3	1,082.2	1,080.2
Change	0.6	0.4	0.1	0.1

(a) Plan A assumes no flow over either dam
(b) Plan B assumes flow over Boydstown Dam but not over Lake Oneida Dam


K·E LOGARITHMIC 2 X 3 CYCLES
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 7323
Tc+R = 11.84 DA^0.184 for condition
R/(Tc+R) = 0.53
Regional Clark Parameters
Drainage Area (sq. mi.)
Clark's Tc+R (hours)


Job 8267 Lake Oneida
Boydstown DAM
Reservoir Inflow, Outflow, Stage
for
Probable Maximum Flood
(based on regional Clark unit hydrographs)
Total Rainfall = 29.5 inches (72 hr. storm)
Total Runoff = 26.2 inches
(b) = flow over spillway and dam (existing)
(a) = flow over spillway only
Outflow (b)
Inflow
Outflow (a)
Stage (a)
Stage (b)
Existing Top of Dam
Stage (a) & (b)
Inflow
Outflow (a) & (b)
Spillway Crest
Discharge (Thousand cfs)
Reservoir Elevation (feet)
Time (Hours)
0
2
4
6
8
10
12
1070
1075
1080
1085
1090
24
36
48
60
72
84
96
108
120
132

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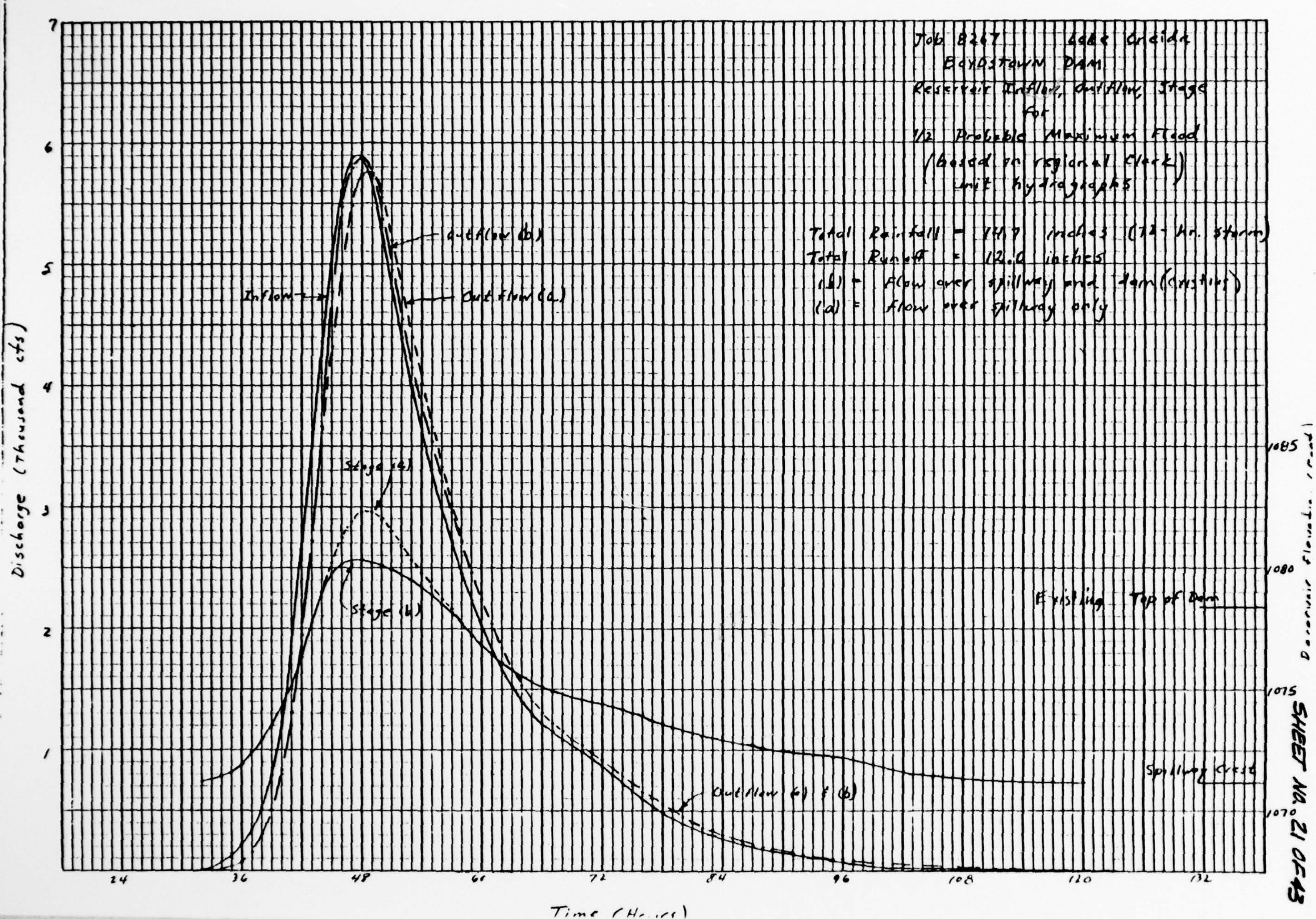
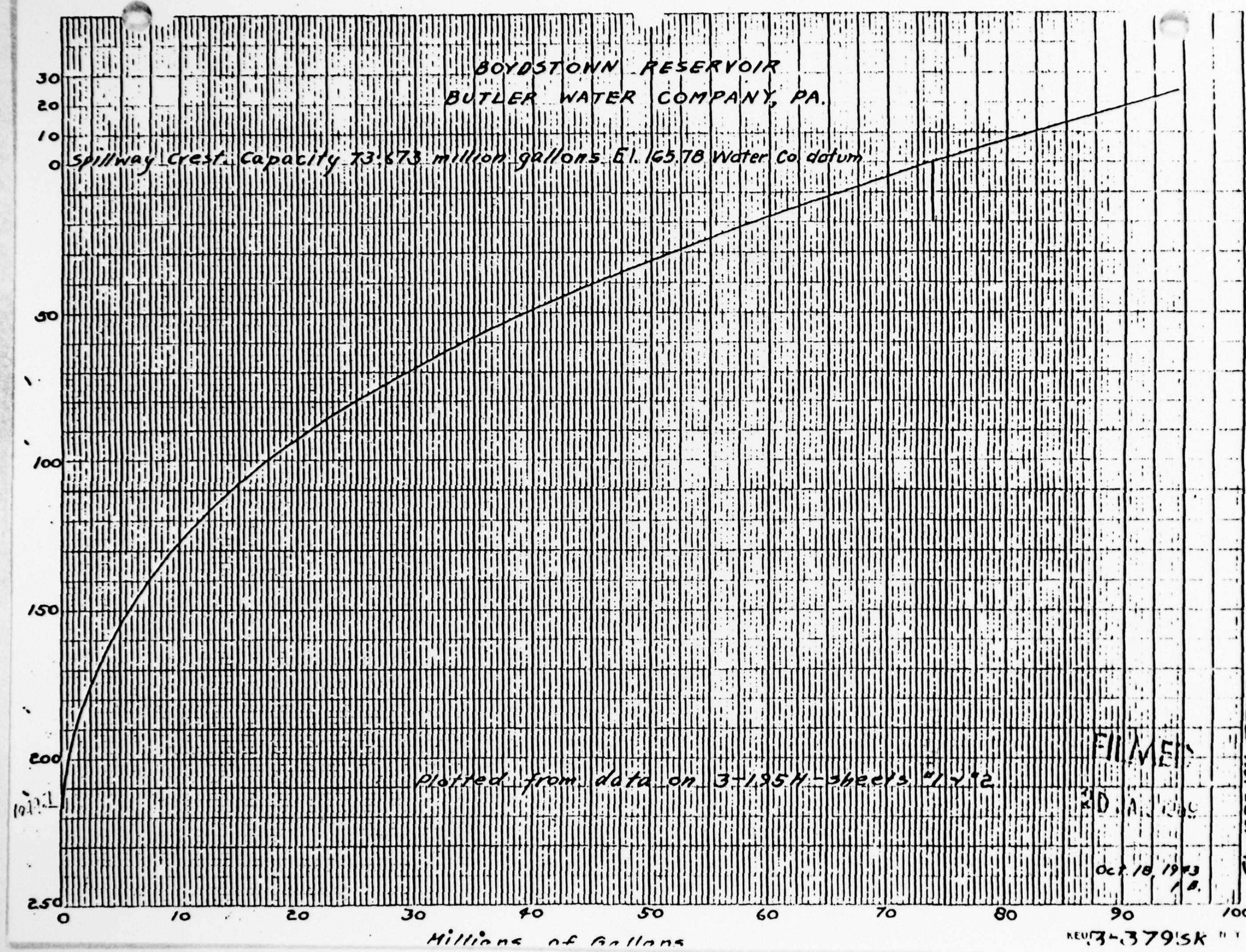
7 X 10 INCHES
MADE IN U.S.A.
KEUFFEL & ESSER CO.




SHEET NO. 22 OF 43
BOYDSTOWN RESERVOIR
BUTLER WATER COMPANY, PA.
Spillway crest Capacity 73.673 million gallons El. 165.78 Water Co datum
Plotted from data on 3-195H-sheets #1-#2
Oct. 18, 1973
30
20
10
0
50
100
150
200
250
0
10
20
30
40
50
60
70
80
90
100
Millions of Gallons
3-379SK

SHEET NO. 23 OF 43

```
**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
 LAST MODIFICATION  26 FEB 79
**********************************
A1      LAKE ONEIDA DAM  JOB 8267  APRIL 1979   G. BIEMEL
A2      ROUTE PMF AND 1/2 PMF THROUGH RESERVOIR    HEC-1 DAM SV
A3      EXISTING SYSTEM, NO FLOW OVER ONEIDA, NO FLOW OVER EITHER DAM
B    130       1       0       0       0       0       0       0       0       0
B1      5
J       3       2       0
J11.0   0.5
K       0       1                                       1
K1      CALCULATE INFLOW TO THE DAM AT BOYDSTOWN
M       1       13.58           16.41                                           1
P       36.79   68.     78.     84.     93.     98.
T                                               1.92    0.029
V 9.00  10.15
X
K       1       2                                       1
K1      ROUTE THROUGH THE DAM AT BOYDSTOWN
Y                               1       0
Y1      1                                              -1
Y2227.  254.    266.    313.    507.    558.    583.    617.    663.    770.
Y30.    100.    200.    700.    3100.   4000.   4820.   6070.   8400.   14750.
Y41071.21072.2  1072.6  1074.0  1078.4  1079.4  1079.8  1080.4  1081.2  1083.0
Y50.    100.    200.    700.    3100.   4000.   4820.   6070.   8400.   14750.
Y                               1       0
Y1      1                                              -1
Y2227.  254.    266.    313.    507.    558.    583.    617.    663.    770.
Y30.    100.    200.    700.    3100.   4000.   4820.   6070.   8400.   14750.
Y41071.21072.2  1072.6  1074.0  1078.4  1079.4  1079.8  1080.4  1081.2  1083.0
Y50.    100.    200.    700.    3100.   4000.   4820.   6070.   8400.   14750.
Y                               1       0
Y1      1                                              -1
Y2227.  254.    266.    313.    507.    754.    833.    988.    1143.   1375.
Y30.    100.    200.    700.    3100.   6000.   7000.   9000.   11000.  14000.
Y41071.21072.2  1072.6  1074.0  1078.4  1082.7  1084.0  1086.6  1089.2  1093.1
Y50.    100.    200.    700.    3100.   6000.   7000.   9000.   11000.  14000.
K       1       3                                       1
K1      TAILWATER STAGES AT BOYDSTOWN DAM
Y                               1       1
Y1      1                                              -1
Y20.    0.1
Y30.    20000.
Y41055.61056.1  1058.2  1060.0  1062.0  1063.0  1064.0  1064.5  1065.1  1067.3
Y50.    200.    620.    1320.   2380.   3000.   3900.   4600.   5900.   14800.
K       0       3                                       1
K1      CALCULATE INFLOW FOR AREA BETWEEN BOYDSTOWN AND ROAD CROSSING
M       1       0.62            16.41                                           1
P       36.79   68.     78.     84.     93.     98.
T                                               1.92    0.029
V 5.09  5.75
X
K       2       3                                       1
```

```
K1      TOTAL INFLOW AT ROAD CROSSING
K       1       4                                               1
K1      ROUTE THROUGH ROAD CROSSING
Y                                       1       1
Y1      1                                                       -1
Y222.   34.     49.     77.     103.    111.    116.    122.    130.    149.
Y30.    550.    1350.   2400.   3950.   4700.   5600.   6800.   9000.   14600.
Y41055.61058.0  1060.0  1062.0  1064.0  1064.6  1065.0  1065.4  1066.0  1067.2
Y50.    550.    1350.   2400.   3950.   4700.   5600.   6800.   9000.   14600.
K       0       4                                               1
K1      CALCULATE INFLOW FOR AREA BETWEEN ONEIDA DAM AND ROAD CROSSING
M       1       2.21            16.41                                           1
P       36.79   68.     78.     84.     93.     98.
T                                               1.92    0.029
V 6.44  7.26
X
K       2       4                                               1
K1      TOTAL INFLOW AT LAKE ONEIDA DAM
K       1       5                                               1
K1      ROUTE THROUGH LAKE ONEIDA DAM
Y                                       1       0
Y1      1                                                       -1
Y20.    492.    800.    1310.   1510.   1600.   1675.   1740.   1835.   1960.
Y30.    1000.   2000.   4000.   6000.   8000.   10000.  12000.  15000.  20000.
Y41055.61058.9  1060.8  1063.8  1064.9  1065.4  1065.8  1066.2  1066.7  1067.4
Y50.    1000.   2000.   4000.   6000.   8000.   10000.  12000.  15000.  20000.
Y                                       1       0
Y1      1                                                       -1
Y20.    492.    800.    1060.   1310.   1760.   2150.   2600.   3000.   3600.
Y30.    1000.   2000.   3000.   4000.   6000.   8000.   10000.  12000.  15000.
Y41055.61058.9  1060.8  1062.4  1063.8  1066.3  1068.6  1071.2  1073.5  1076.8
Y50.    1000.   2000.   3000.   4000.   6000.   8000.   10000.  12000.  15000.
Y                                       1       0
Y1      1                                                       -1
Y20.    492.    800.    1060.   1310.   1760.   2150.   2600.   3000.   3600.
Y30.    1000.   2000.   3000.   4000.   6000.   8000.   10000.  12000.  15000.
Y41055.61058.9  1060.8  1062.4  1063.8  1066.3  1068.6  1071.2  1073.5  1076.8
Y50.    1000.   2000.   3000.   4000.   6000.   8000.   10000.  12000.  15000.
K       1       6                                               1
K1      TAILWATER STAGES AT LAKE ONEIDA DAM
Y                                       1       1
Y1      1                                                       -1
Y20.    0.1
Y30.    20000.
Y41030.01031.8  1032.4  1033.4  1034.8  1035.8  1036.6  1037.4  1038.2  1039.3
Y50.    600.    1000.   2000.   4000.   6000.   8000.   10000.  12000.  15000.
K       99
```

SHEET NO. 25 OF 43

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO PRECIPITATION RATIO 1 1.00	RATIO 2 .50
HYDROGRAPH AT	1	13.58	1	12175.	5875.
	(	35.17)	(	344.77)(	166.35)(
			2	12175.	5875.
			(	344.77)(	166.35)(
			3	12175.	5875.
			(	344.77)(	166.35)(
ROUTED TO	2	13.58	1	12188.	5888.
	(	35.17)	(	345.12)(	166.73)(
			2	12188.	5888.
			(	345.12)(	166.73)(
			3	11968.	5745.
			(	338.89)(	162.69)(
ROUTED TO	3	13.58	1	12188.	5888.
	(	35.17)	(	345.12)(	166.73)(
			2	12188.	5888.
			(	345.12)(	166.73)(
			3	11968.	5745.
			(	338.89)(	162.69)(
HYDROGRAPH AT	3	.62	1	861.	422.
	(	1.61)	(	24.39)(	11.94)(
			2	861.	422.
			(	24.39)(	11.94)(
			3	861.	422.
			(	24.39)(	11.94)(
2 COMBINED	3	14.20	1	12754.	6157.
	(	36.78)	(	361.17)(	174.35)(
			2	12754.	6157.
			(	361.17)(	174.35)(
			3	12521.	6008.
			(	354.55)(	170.13)(
ROUTED TO	4	14.20	1	12776.	6166.
	(	36.78)	(	361.78)(	174.61)(
			2	12776.	6166.
			(	361.78)(	174.61)(
			3	12493.	6014.
			(	353.76)(	170.30)(
HYDROGRAPH AT	4	2.21	1	2581.	1257.
	(	5.72)	(	73.09)(	35.60)(
			2	2581.	1257.
			(	73.09)(	35.60)(
			3	2581.	1257.
			(	73.09)(	35.60)(

SHEET NO. 26 OF 43

```
2 COMBINED         4      16.41        1     15127.       7244.
                   (      42.50)       (    428.36)(   205.13)(
                                       2     15127.       7244.
                                       (    428.36)(   205.13)(
                                       3     14604.       7040.
                                       (    413.53)(   199.35)(

ROUTED TO          5      16.41        1     14984.       7121.
                   (      42.50)       (    424.30)(   201.64)(
                                       2     13582.       6320.
                                       (    384.61)(   178.96)(
                                       3     13344.       6242.
                                       (    377.87)(   176.76)(

ROUTED TO          6      16.41        1     14984.       7121.
                   (      42.50)       (    424.31)(   201.64)(
                                       2     13582.       6320.
                                       (    384.61)(   178.96)(
                                       3     13344.       6242.
                                       (    377.87)(   176.76)(
```

PLAN 1 STATION 2

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	12188.	1082.3	48.00
.50	5888.	1080.3	48.00

Boydstown Dam
(Existing Conditions)

PLAN 2 STATION 2

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	12188.	1082.3	48.00
.50	5888.	1080.3	48.00

PLAN 3 STATION 2

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	11968.	1090.5	48.00
.50	5745.	1082.3	49.00

PLAN 1 STATION 3

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	12188.	1066.7	48.00
.50	5888.	1065.1	48.00

PLAN 2 STATION 3

MAXIMUM MAXIMUM TIME

RATIO	FLOW,CFS	STAGE,FT	HOURS
1.00	12188.	1066.7	48.00
.50	5888.	1065.1	48.00

PLAN 3 STATION 3

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	11968.	1066.6	48.00
.50	5745.	1065.0	49.00

PLAN 1 STATION 4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	12776.	1066.8	47.00
.50	6166.	1065.2	48.00

PLAN 2 STATION 4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	12776.	1066.8	47.00
.50	6166.	1065.2	48.00

PLAN 3 STATION 4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	12493.	1066.7	48.00
.50	6014.	1065.1	48.00

PLAN 1 STATION 5

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	14984.	1066.7	47.00
.50	7121.	1065.2	48.00

PLAN 2 STATION 5

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	13582.	1075.2	50.00
.50	6320.	1066.7	50.00

PLAN 3 STATION 5

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	13344.	1075.0	50.00
.50	6242.	1066.6	51.00

PLAN 1 STATION 6

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	14984.	1039.3	47.00
.50	7121.	1036.2	48.00

PLAN 2 STATION 6

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	13582.	1038.8	50.00
.50	6320.	1035.9	50.00

PLAN 3 STATION 6

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	13344.	1038.7	50.00
.50	6242.	1035.9	51.00

Note: Plan 1- Existing conditions
Plan 2- No flow over Oneida Dam
Plan 3- No flow over either Dam

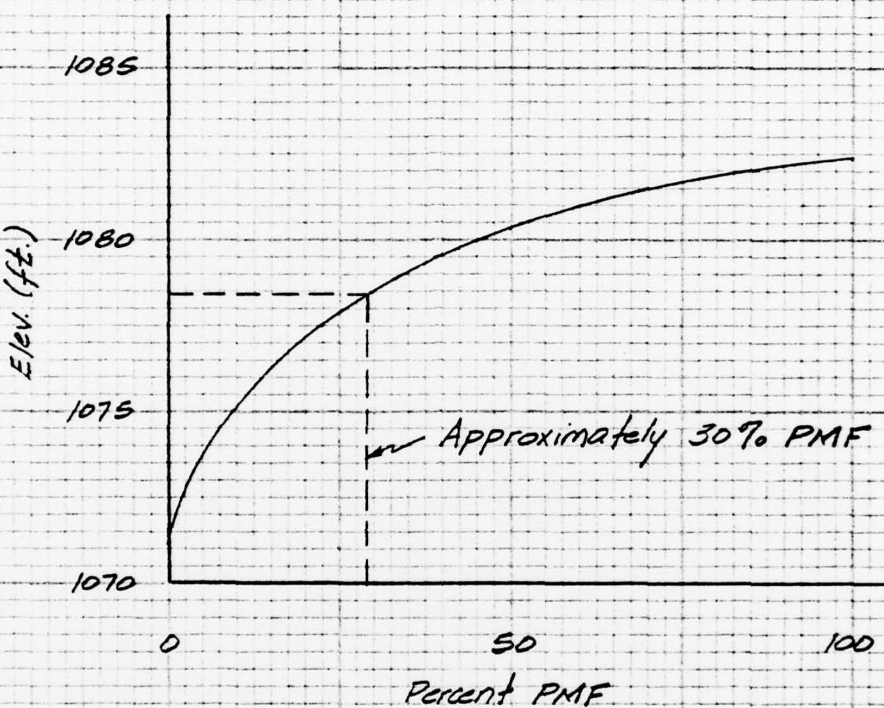
MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject Boydstown Dam
Overtopping Potential

S.O. No. ____
Sheet No. 29 of 43
Drawing No. ____

Computed by REH   Checked by ____   Date 7-27-79



Note: This was determined from the results of the Burgess and Niple overtopping analysis.

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*****  *****************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION       JULY 1978
  LAST MODIFICATION   26 FEB 79
  MBJ UPDATE          04 JUN 79
***********************************
A1      BOYDSTOWN DAM   DATA TAKEN FROM BURGESS AND NIPLE STUDY
A2      DAM BREACH ANALYSIS FOR BOYDSTOWN DAM-0.5 PMF
A3      BALTIMORE DISTRICT U.S. ARMY COE
B    250       0      20       0       0       0       0       0      -4       0
B1     5
J      2       1
J1   0.5
K      0       1                                       1
K1      CALCULATE INFLOW TO THE DAM AT BOYDSTOWN
M      1           13.58           16.41                                   1
P          36.79      68      78      84      93      98
T                                                   1.92   0.029
V      9   10.15
X
K      1       2                                       1
K1      ROUTE THROUGH THE DAM AT BOYDSTOWN
Y                              1       1
Y1     1                                         -1071.2      -1
Y41071.2  1072.2  1072.6    1074  1078.4  1079.4  1079.8  1080.4  1080.8  1081.2
Y41081.4  1081.8  1083.0
Y5     0     100     200     700    3100    4000    4820    6070    7200    8400
Y5  9030   10400   14750
$S     0      14      42     105     200     350     592     900
$E  1049    1055    1060    1065    1070    1075    1080    1085
$$1071.2
$D1078.4
$B   100     0.5    1055       2  1071.2    1090
$B   100     0.5    1055       2  1071.2  1079.4
K      1       3                                       1
K1      TAILWATER STAGES AT BOYDSTOWN DAM
Y                              1       1
Y1     1                                         -1055.6      -1
Y41055.6  1056.1  1058.2    1060    1062    1063    1064  1064.5  1065.1  1065.5
Y41066.0  1066.2  1066.5  1067.0  1067.3
Y5     0     200     620    1320    2380    3000    3900    4600    5900    7730
Y5  8500   10240   11370   13250   14800
$S     0       1
$E1055.6  1067.3
$$1055.6
$D  1067
K      0       3                                       1
K1      CALCULATE INFLOW FOR AREA BETWEEN BOYDSTOWN AND ROAD CROSSING
M      1            0.62           16.41                                   1
P          36.79      68      78      84      93      98
T                                                   1.92    .029
V   5.09    5.75
X
K      2       3                                       1
K1      TOTAL INFLOW AT ROAD CROSSING
K      1       4                                       1
```

SHEET NO. 30 OF 43

```
K1      ROUTE THROUGH ROAD CROSSING
Y                                  1        1
Y1    1                                                -1055.6      -1
Y41055.6    1058     1060     1062     1064   1064.6     1065   1065.4     1066   1066.3
Y41066.5  1067.0   1067.2
Y5    0      550     1350     2400     3950     4700     5600     6800     9000    10250
Y5 11100   13500    14600
$S   22       34       49       77      103      111      116      122      130      149
$E1055.6    1058     1060     1062     1064   1064.6     1065   1065.4     1066   1067.2
$$1055.6
$D  1067
K     0        4                                              1
K1      CALCULATE INFLOW FOR AREA BETWEEN ONEIDA DAM AND ROAD CROSSING
M     1                 2.21              16.41                                   1
P          36.79       68       78       84       93       98
T                                                        1.92    0.029
V  6.44     7.26
X
K     2        4                                              1
K1      TOTAL INFLOW AT LAKE ONEIDA DAM
K     1        5                                              1
K1      ROUTE THROUGH LAKE ONEIDA DAM
Y                                  1        1
Y1    1                                                -1055.6      -1
Y41055.6  1058.9   1060.8   1063.8   1064.9   1065.4   1065.8   1066.2   1066.7   1067.4
Y5    0     1000     2000     4000     6000     8000    10000    12000    15000    20000
$S    0      492      800     1310     1510     1600     1675     1740  [illegible]   1960
$E1055.6  1058.9   1060.8   1063.8   1064.9   1065.4   1065.8   1066.2  [illegible] 1067.4
$$1055.6
$D1063.7
K    99
```

SHEET NO. 31 OF 43

SHEET NO. 32 OF 43

```
**********************************
FLOOD  ROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION       JULY 1978
  LAST MODIFICATION  26 FEB 79
  MBJ UPDATE          04 JUN 79
**********************************

RUN  DATE 08/02/79
     TIME     11.11

                    BOYDSTOWN DAM   DATA TAKEN FROM BURGESS AND NIPLE STUDY
                    DAM BREACH ANALYSIS FOR BOYDSTOWN DAM-0.5 PMF
                    BALTIMORE DISTRICT U.S. ARMY COE

                                   JOB SPECIFICATION
             NQ      NHR     NMIN     IDAY      IHR     IMIN    METRC     IPLT     IPRT    NSTAN
            250        0       20        0        0        0        0        0       -4        0
                                     JOPER      NWT    LROPT    TRACE
                                         5        0        0        0        0

                              MULTI-PLAN ANALYSES TO BE PERFORMED
                                 NPLAN= 2 NRTIO= 1 LRTIO= 0
         RTIOS=    0.50

      **********        **********        **********        **********        **********

                                SUB-AREA RUNOFF COMPUTATION

            CALCULATE INFLOW TO THE DAM AT BOYDSTOWN

                         ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                             1       0       0       0       0       0       1       0       0

                                    HYDROGRAPH DATA
         IHYDG    IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
             1       0   13.58     0.0   16.41     0.0     0.0       0       1       0

                                     PRECIP DATA
                    SPFE     PMS      R6     R12     R24     R48     R72     R96
                     0.0   36.79   68.00   78.00   84.00   93.00   98.00     0.0
TRSPC COMPUTED BY THE PROGRAM IS 0.817

                                      LOSS DATA
      LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
          0     0.0     0.0    1.00     0.0     0.0    1.00    1.92    0.03     0.0     0.0

                                UNIT HYDROGRAPH DATA
                            TC=  9.00     R= 10.15     NTA=  0

                                    RECESSION DATA
                        STRTQ=     0.0     QRCSN=     0.0     RTIOR= 1.00

         UNIT HYDROGRAPH176 END-OF-PERIOD ORDINATES, LAG=   8.61 HOURS, CP= 0.55  VOL= 1.00
          4.       16.       34.       55.       79.      105.      133.      162.      193.      226.
        259.      293.      328.      364.      398.      429.      458.      484.      507.      527.
        544.      557.      568.      575.      579.      578.      572.      557.      539.      522.
        505.      489.      473.      458.      443.      429.      415.      401.      388.      376.
```

SHEET NO. 33 OF 43

```
    364.      352.      341.      330.      319.      309.      299.      289.      280.      271.
    262.      253.      245.      237.      230.      222.      215.      208.      201.      195.
    189.      182.      177.      171.      165.      160.      155.      150.      145.      140.
    136.      131.      127.      123.      119.      115.      111.      108.      104.      101.
     98.       95.       92.       89.       86.       83.       80.       78.       75.       73.
     70.       68.       66.       64.       62.       60.       58.       56.       54.       52.
     51.       49.       47.       46.       44.       43.       42.       40.       39.       38.
     36.       35.       34.       33.       32.       31.       30.       29.       28.       27.
     26.       25.       25.       24.       23.       22.       22.       21.       20.       20.
     19.       18.       18.       17.       17.       16.       16.       15.       15.       14.
     14.       13.       13.       12.       12.       12.       11.       11.       10.       10.
     10.        9.        9.        9.        9.        8.        8.        8.        8.        7.
      7.        7.        7.        6.        6.        6.        6.        6.        5.        5.
      5.        5.        5.        5.        4.        4.

                                        END-OF-PERIOD FLOW
     0
MO.DA  HR.MN  PERIOD  RAIN  EXCS  LOSS  COMP Q     MO.DA  HR.MN  PERIOD  RAIN   EXCS   LOSS   COMP Q

                                                          SUM   29.45  26.19   3.25   669594.
                                                               ( 748.)( 665.)(  83.)(18960.82)

            TOTAL RAIN  14.72, TOTAL RAINFALL EXCESS  11.99, TOTAL FLOW   306470.

     **********     **********     **********     **********     **********

                                  HYDROGRAPH ROUTING

            ROUTE THROUGH THE DAM AT BOYDSTOWN

                    ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                        2       1       0       0       0       0       1       0       0

                                  ALL PLANS HAVE SAME
                                     ROUTING DATA
            QLOSS   CLOSS     AVG    IRES   ISAME    IOPT    IPMP            LSTR
              0.0     0.0     0.0       1       1       0       0               0

                    NSTPS   NSTDL     LAG   AMSKK       X     TSK   STORA  ISPRAT
                        1       0       0     0.0     0.0     0.0  -1071.      -1

STAGE      1071.20   1072.20   1072.60   1074.00   1078.40   1079.40   1079.80   1080.40   1080.80   1081.20
           1081.40   1081.80   1083.00

FLOW          0.0     100.00    200.00    700.00   3100.00   4000.00   4820.00   6070.00   7200.00   8400.00
           9030.00  10400.00  14750.00

CAPACITY=       0.       14.       42.      105.      200.      350.      5?2.      900.

ELEVATION=   1049.     1055.     1060.     1065.     1070.     1075.     1080.     1085.

                     CREL   SPWID    COQW    EXPW   ELEVL    COQL   CAREA    EXPL
                   1071.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0

                                        DAM DATA
                               TOPEL    COQD    EXPD  DAMWID
                              1078.4     0.0     0.0      0.

                                        DAM BREACH DATA
                           BRWID       Z    ELBM   TFAIL    WSEL  FAILEL
                            100.    0.50  1055.00   2.00  1071.20  1090.00

PEAK OUTFLOW IS      5904. AT TIME   47.67 HOURS
```

AD-A078 947 BAKER (MICHAEL) JR INC BEAVER PA F/G 13/13
NATIONAL DAM INSPECTION PROGRAM. BOYDSTOWN DAM (NDI NUMBER PA-0--ETC(U)
AUG 79 C Y CHEN DACW31-79-C-0011

UNCLASSIFIED NL

2 OF 2

AD
A078947

END
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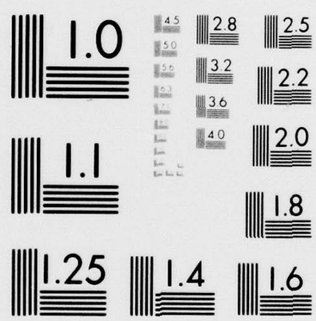

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

```
                                                    DAM BREACH DATA
                                        BRWIC        Z    ELBM    TFAIL    WSEL  FAILEL
                                         100.     0.50 1055.00     2.00 1071.20 1079.40
BEGIN DAM FAILURE AT 44.33 HOURS

PEAK OUTFLOW IS      9676. AT TIME  45.37 HOURS


            **********          **********          **********          **********          **********

                                                 HYDROGRAPH ROUTING

                          TAILWATER STAGES AT BOYDSTOWN DAM

                                  ISTAQ    ICOMP    IECON    ITAPE     JPLT     JPRT    INAME   ISTAGE    IAUTO
                                      3        1        0        0        0        0        1        0        0

                                                 ALL PLANS HAVE SAME
                                                     ROUTING DATA
                           QLOSS    CLOSS      AVG     IRES    ISAME     IOPT     IPMP              LSTR
                             0.0      0.0      0.0        1        1        0        0                 0

                                  NSTPS    NSTDL      LAG    AMSKK        X      TSK    STORA   ISPRAT
                                      1        0        0      0.0      0.0      0.0   -1056.       -1

     STAGE      1055.60     1056.10     1058.20     1060.00     1062.00     1063.00     1064.00     1064.50     1065.10     1065.50
                1066.00     1066.20     1066.50     1067.00     1067.30

      FLOW          0.0      200.00      620.00     1320.00     2380.00     3000.00     3900.00     4600.00     5900.00     7730.00
                8500.00    10240.00    11370.00    13250.00    14800.00

    CAPACITY=        0.         1.

   ELEVATION=      1056.      1067.

                              CREL    SPWIC     COQW     EXPW    ELEVL     COQL    CAREA     EXPL
                            1055.6      0.0      0.0      0.0      0.0      0.0      0.0      0.0

                                                    DAM DATA
                                             TOPEL     COQD     EXPD   DAMWID
                                            1067.0      0.0      0.0       0.

PEAK OUTFLOW IS      5903. AT TIME  47.67 HOURS

PEAK OUTFLOW IS      9573. AT TIME  45.33 HOURS


            **********          **********          **********          **********          **********

                                              SUB-AREA RUNOFF COMPUTATION

                          CALCULATE INFLOW FOR AREA BETWEEN BOYDSTOWN AND ROAD CROSSING

                                  ISTAQ    ICOMP    IECON    ITAPE     JPLT     JPRT    INAME   ISTAGE    IAUTO
                                      3        C        0        0        0        0        1        0        0

                                                  HYDROGRAPH DATA
                        IHYDG     IUHG    TAREA     SNAP    TRSDA    TRSPC    RATIO    ISNOW    ISAME    LCCAL
                            1        0     0.62      0.0    16.41      0.0      0.0        0        1        0
```

SHEET NO. 34 OF 43

SHEET NO. 35 OF 43

```
                                   PRECIP DATA
             SPFE      PMS       R6      R12      R24      R48      R72      R96
              0.0    36.79    68.00    78.00    84.00    93.00    98.00      0.0
TRSP. COMPUTED BY THE PROGRAM IS 0.817

                                    LOSS DATA
     LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
         0     0.0     0.0    1.00     0.0     0.0    1.00    1.92    0.03     0.0     0.0

                              UNIT HYDROGRAPH DATA
                         TC=  5.09      R=  5.75      NTA=  0

                                  RECESSION DATA
                   STRTQ=     0.0     QRCSN=      0.0     RTIOR= 1.00

      UNIT HYDROGRAPH100 END-OF-PERIOD ORDINATES, LAG=   4.80 HOURS, CP= 0.54   VOL= 1.00
         1.         3.         6.        10.        14.        19.        24.        29.        33.        38.
        41.        44.        45.        46.        46.        45.        43.        40.        38.        36.
        34.        32.        30.        28.        27.        25.        24.        22.        21.        20.
        19.        18.        17.        16.        15.        14.        13.        13.        12.        11.
        11.        10.         9.         9.         8.         8.         7.         7.         7.         6.
         6.         6.         5.         5.         5.         4.         4.         4.         4.         4.
         3.         3.         3.         3.         3.         2.         2.         2.         2.         2.
         2.         2.         2.         2.         1.         1.         1.         1.         1.         1.
         1.         1.         1.         1.         1.         1.         1.         1.         1.         1.
         1.         1.         1.         0.         0.         0.         0.         0.         0.         0.

      0                                END-OF-PERIOD FLOW
  MO.DA  HR.MN  PERIOD   RAIN   EXCS   LOSS   COMP Q      MO.DA  HR.MN  PERIOD   RAIN   EXCS   LOSS    COMP Q

                                                                          SUM  29.45  26.19   3.25    31212.
                                                                             ( 748.)( 665.)(  83.)(  883.83)

                  TOTAL RAIN  14.72, TOTAL RAINFALL EXCESS  11.99, TOTAL FLOW    14296.


         **********         **********         **********         **********         **********

                                 COMBINE HYDROGRAPHS

                  TOTAL INFLOW AT ROAD CROSSING

                        ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                            3       2       0       0       0       0       1       0       0


         **********         **********         **********         **********         **********

                                 HYDROGRAPH ROUTING

                  ROUTE THROUGH ROAD CROSSING

                        ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                            4       1       0       0       0       0       1       0       0

                                 ALL PLANS HAVE SAME
                                     ROUTING DATA
                   QLOSS   CLOSS     AVG    IRES   ISAME    IOPT    IPMP            LSTR
                     0.0     0.0     0.0       1       1       0       0               0

                        NSTPS   NSTDL     LAG   AMSKK       X     TSK   STORA  ISPRAT
                            1       0       0     0.0     0.0     0.0  -1056.      -1
```

SHEET NO. 36 OF 43

```
STAGE    1055.60    1058.00    1060.00    1062.00    1064.00    1064.60    1065.00    1065.40    1066.00    1066.30
         1066.50    1067.00    1067.20

FLOW         0.0     550.00    1350.00    2400.00    3950.00    4700.00    5600.00    6800.00    9000.00   10250.00
        11100.00   13500.00   14600.00

CAPACITY=      22.       34.       49.       77.      103.      111.      116.      122.      130.      149.

ELEVATION=   1056.     1058.     1060.     1062.     1064.     1065.     1065.     1065.     1066.     1067.

                    CREL    SPWID    COQW    EXPW    ELEVL    COQL    CAREA    EXPL
                  1055.6      0.0     0.0     0.0      0.0     0.0      0.0     0.0

                                       DAM DATA
                              TOPEL    COQD    EXPD   DAMWID
                             1067.0     0.0     0.0      0.

PEAK OUTFLOW IS     6182. AT TIME  47.67 HOURS

PEAK OUTFLOW IS     9714. AT TIME  45.33 HOURS


     **********        **********        **********        **********        **********

                               SUB-AREA RUNOFF COMPUTATION

                 CALCULATE INFLOW FOR AREA BETWEEN ONEIDA DAM AND ROAD CROSSING

                     ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                         4       0       0       0       0       0       1       0       0

                                      HYDROGRAPH DATA
              IHYDG    IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
                  1       0    2.21     0.0   16.41     0.0     0.0       0       1       0

                                        PRECIP DATA
                    SPFE     PMS      R6     R12     R24     R48     R72     R96
                     0.0   36.79   68.00   78.00   84.00   93.00   98.00     0.0
TRSPC COMPUTED BY THE PROGRAM IS 0.817

                                         LOSS DATA
         LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
             0     0.0     0.0    1.00     0.0     0.0    1.00    1.92    0.03     0.0     0.0

                                  UNIT HYDROGRAPH DATA
                            TC=  6.44     R=  7.26    NTA=   0

                                      RECESSION DATA
                   STRTQ=     0.0    GRCSN=    0.0    RTIOR= 1.00

      UNIT HYDROGRAPH126 END-OF-PERIOD ORDINATES, LAG=   6.13 HOURS, CP= 0.55  VOL= 1.00
       2.        6.       12.       20.       29.       38.       48.       59.       70.       81.
      92.      101.      110.      117.      123.      127.      130.      132.      131.      128.
     122.      117.      111.      106.      102.       97.       93.       89.       85.       81.
      77.       74.       70.       67.       64.       61.       59.       56.       53.       51.
      49.       47.       44.       42.       41.       39.       37.       35.       34.       32.
      31.       29.       28.       27.       26.       24.       23.       22.       21.       20.
      19.       19.       18.       17.       16.       15.       15.       14.       13.       13.
      12.       12.       11.       11.       10.       10.        9.        9.        9.        8.
       8.        7.        7.        7.        6.        6.        6.        6.        5.        5.
```

```
   5.      5.      4.      4.      4.      4.      4.      4.      3.      3.
   3.      3.      3.      3.      3.      2.      2.      2.      2.      2.
   2.      2.      2.      2.      2.      2.      1.      1.      1.      1.
   1.      1.      1.      1.      1.      1.

   0                                   END-OF-PERIOD FLOW
 MO.DA  HR.MN  PERIOD   RAIN   EXCS   LOSS   COMP Q      MO.DA  HR.MN  PERIOD   RAIN   EXCS   LOSS   COMP Q

                                                                        SUM  29.45  26.19   3.25  111036.
                                                                          ( 748.)( 665.)(  83.)( 3144.19)

                 TOTAL RAIN  14.72, TOTAL RAINFALL EXCESS  11.99, TOTAL FLOW    50838.

          *********         *********         *********         *********         *********

                                         COMBINE HYDROGRAPHS

                 TOTAL INFLOW AT LAKE ONEIDA DAM

                          ISTAQ   ICOMP   IECON   ITAPE   JPLT   JPRT   INAME  ISTAGE  IAUTO
                              4       2       0       0      0      0       1       0      0

          *********         *********         *********         *********         *********

                                         HYDROGRAPH ROUTING

                 ROUTE THROUGH LAKE ONEIDA DAM

                          ISTAQ   ICOMP   IECON   ITAPE   JPLT   JPRT   INAME  ISTAGE  IAUTO
                              5       1       0       0      0      0       1       0      0

                                         ALL PLANS HAVE SAME
                                            ROUTING DATA
                 QLOSS   CLOSS     AVG    IRES   ISAME   IOPT   IPMP            LSTR
                   0.0     0.0     0.0       1       1      0      0               0

                          NSTPS   NSTDL    LAG   AMSKK      X     TSK   STORA  ISPRAT
                              1       0      0     0.0    0.0     0.0  -1056.      -1

 STAGE     1055.60   1058.90   1060.80   1063.80   1064.90   1065.40   1065.80   1066.20   1066.70   1067.40

 FLOW          0.0   1000.00   2000.00   4000.00   6000.00   8000.00  10000.00  12000.00  15000.00  20000.00

 CAPACITY=       0.      492.      800.     1310.     1510.     1600.     1675.     1740.     1835.     1960.

 ELEVATION=   1056.     1059.     1061.     1064.     1065.     1065.     1066.     1066.     1067.     1067.

                       CREL   SPWID    COQW    EXPW   ELEVL    COOL   CAREA    EXPL
                     1055.6     0.0     0.0     0.0     0.0     0.0     0.0     0.0

                                                 DAM DATA
                                      TOPEL    COQD    EXPD   DAMWID
                                     1063.7     0.0     0.0       0.

 PEAK OUTFLOW IS     7096. AT TIME  48.33 HOURS

 PEAK OUTFLOW IS     9186. AT TIME  46.33 HOURS
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SHEET NO. 38 OF 43

********** ********** ********** ********** **********

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

RATIOS APPLIED TO PRECIPITATION

OPERATION	STATION	AREA	PLAN	RATIO 1 0.50	
HYDROGRAPH AT	1	13.58	1	5922.	
	(	35.17)	(	167.70)(	
			2	5922.	
			(	167.70)(	
ROUTED TO	2	13.58	1	5904.	
	(	35.17)	(	167.17)(	Boydstown Dam
			2	9579.	
			(	271.23)(	
ROUTED TO	3	13.58	1	5903.	
	(	35.17)	(	167.16)(	
			2	9573.	
			(	271.07)(	
HYDROGRAPH AT	3	0.62	1	425.	
	(	1.61)	(	12.04)(	
			2	425.	
			(	12.04)(	
2 COMBINED	3	14.20	1	6185.	
	(	36.78)	(	175.15)(	
			2	9967.	
			(	282.25)(	
ROUTED TO	4	14.20	1	6182.	
	(	36.78)	(	175.07)(	
			2	9714.	
			(	275.06)(	
HYDROGRAPH AT	4	2.21	1	1269.	
	(	5.72)	(	35.94)(	
			2	1269.	
			(	35.94)(	
2 COMBINED	4	16.41	1	7270.	
	(	42.50)	(	205.85)(	
			2	10963.	
			(	311.00)(	
ROUTED TO	5	16.41	1	7096.	
	(	42.50)	(	200.93)(	Oneida Dam
			2	9186.	
			(	260.11)(	

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1071.20	1071.20	1078.40
STORAGE	236.	236.	515.
OUTFLOW	0.	0.	3100.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.50	1080.32	1.92	612.	5904.	12.67	47.67	0.0

PLAN 2 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1071.20	1071.20	1078.40
STORAGE	236.	236.	515.
OUTFLOW	0.	0.	3100.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.50	1079.45	1.05	565.	9676.	1.46	45.37	44.33

Station - Boydstown Dam

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1055.60	1055.60	1067.00
STORAGE	0.	0.	1.
OUTFLOW	0.	0.	13250.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.50	1065.10	0.0	1.	5903.	0.0	47.67	0.0

PLAN 2 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1055.60	1055.60	1067.00
STORAGE	0.	0.	1.
OUTFLOW	0.	0.	13250.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.50	1066.12	0.0	1.	9573.	0.0	45.33	0.0

Station - Tailwater at Boydstown Dam

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1055.60	1055.60	1067.00
STORAGE	22.	22.	146.
OUTFLOW	0.	0.	13500.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.50	1065.19	0.0	119.	6182.	0.0	47.67	0.0

PLAN 2 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1055.60	1055.60	1067.00
STORAGE	22.	22.	146.
OUTFLOW	0.	0.	13500.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.50	1066.17	0.0	133.	9714.	0.0	45.33	0.0

station - Road crossing downstream from Boydstown Dam.

SHEET No. 41 OF 43

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1055.60	1055.60	1063.70
STORAGE	0.	0.	1293.
OUTFLOW	0.	0.	3933.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.50	1065.17	1.47	1559.	7096.	11.00	48.33	0.0

PLAN 2 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1055.60	1055.60	1063.70
STORAGE	0.	0.	1293.
OUTFLOW	0.	0.	3933.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.50	1065.64	1.94	1644.	9186.	11.33	46.33	0.0

Station- Oneida Dam

The parameters used in the dam breach analysis were chosen based on the dam failures of 1897 and 1903. Both failures resulted in a breach approximately 100 feet wide. The breaches, which took only a short time to develop, resulted from an overtopping of 1 ft. or less. The time to completely form the breach was determined to be 2 hours. This was based on the fact that a central core wall was constructed following the failures of 1897 & 1903. This wall would not fail as rapidy as the remainder of the earth embankment.

The results of the dam breach analysis indicate that the reservoir level at Oneida dam would be increased by approximately one-half foot in the event of an overtopping failure of Boydstown Dam during 1/2 PMF conditions. This corresponds to an increased discharge of 1700* c.f.s. over Oneida Dam. This increase is considered significant and could contribute to an overtopping failure of Oneida Dam.

* See discharge rating curves prepared by Burgess and Niple (this appendix).

APPENDIX E

REGIONAL GEOLOGY

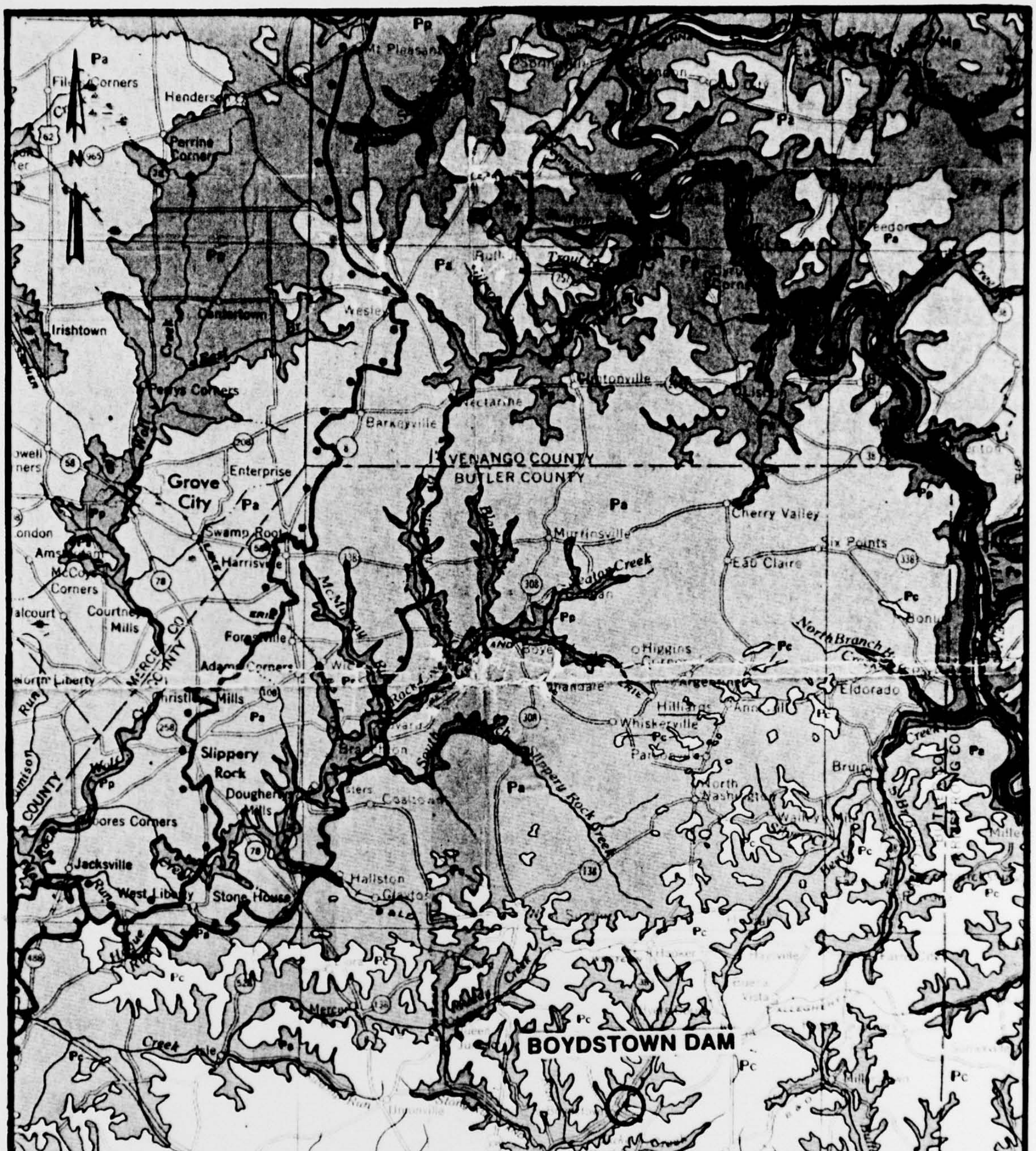
BOYDSTOWN DAM
NDI No. PA 00270, PennDER No. 10-1

REGIONAL GEOLOGY

Boydstown Dam is located in the unglaciated Kanawha section of the Appalachian Plateaus Physiographic Province, a mature plateau region with moderate relief. (Because the dam is old, no specific foundation or geologic data is available from design studies.)

As shown on the following Geologic Map, the dam and reservoir are located in a portion of the Connoquenessing Creek valley which is underlain by members of the Allegheny Formation, Pennsylvanian System. Bedrock in this formation is typically cyclic sequences of sandstone, shale, limestone and coal. The dam is located near the axis of the Mount Nebo syncline; although the dip is slight, the syncline plunges gently to the southwest.

The Upper Freeport coal horizon, the uppermost unit the the Allegheny Formation, is located roughly 100 feet higher than the reservoir.



GEOLOGIC MAP
Boydstown Dam
NDI No. PA 00270 Butler County

Reproduced from Geologic Map of Pennsylvania, Pennsylvania Geological Survey, 4th Series

Scale: One Inch Equals Approximately Four Miles
See Legend, Next Page

PERMIAN

Greene Formation

Cyclic sequences of sandstone, shale, red beds, limestone and coal; base at the top of the Upper Washington Limestone.

PERMIAN AND PENNSYLVANIAN

Washington Formation

Cyclic sequences of sandstone, shale, limestone and coal; some red shale, some mineable coal; base at the top of the Waynesburg Coal.

PENNSYLVANIAN

APPALACHIAN PLATEAU

Pm

Monongahela Formation

Cyclic sequences of sandstone, shale, limestone and coal; limestone prominent in northern outcrop areas, shale and sandstone increase southward; commercial coals present; base at the bottom of the Pittsburgh Coal.

Pc

Conemaugh Formation

Cyclic sequences of red and gray shales and siltstones with thin limestones and coals; massive Mahoning Sandstone commonly present at base; Ames Limestone present in middle of sections; Brush Creek Limestone in lower part of section.

Pa

Allegheny Group

Cyclic sequences of sandstone, shale, limestone and coal; numerous commercial coals; limestones thicken westward; Vanport Limestone in lower part of section; includes Freeport, Kittanning, and Clarion Formations.

Pottsville Group

Predominantly sandstones and conglomerates with thin shales and coals; some coals mineable locally.

ANTHRACITE REGION

Ppp

Post-Pottsville Formations

Brown or gray sandstones and shales with some conglomerate and numerous mineable coals.

Pottsville Group

Light gray to white, coarse grained sandstones and conglomerates with some mineable coal; includes Sharp Mountain, Schuylkill, and Tumbling Run Formations.

MISSISSIPPIAN

Mmc

Mauch Chunk Formation

Red shales with brown to greenish gray flaggy sandstones; includes Greenbrier Limestone in Fayette, Westmoreland, and Somerset counties, Loyalhanna Limestone at the base in southwestern Pennsylvania.

Pocono Group

Predominantly gray, hard, massive, cross-bedded conglomerate and sandstone with some shale; includes in the Appalachian Plateau Burgoon, Shenango, Cuyahoga, Cussewago, Corry, and Knapp Formations; includes part of "Oswayo" of M. L. Fuller in Potter and Tioga counties.